A Biomass System Perspective Framework for a net zero future

As part of the Biomass and Carbon Neutrality project

Host
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Presentation
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About the Institut de l’énergie Trottier

POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D’INGÉNIERIE

Created in 2013 with funding from the Trottier Family Foundation, support renewed in 2023

FONDATION FAMILIALE TROTTIER FAMILY FOUNDATION

Mission

Mobilising science and governance to help catalyse the transition towards low-carbon Canadian energy systems

- **Analysis and guidance** - Help design solutions to energy challenges, guide public policy and support key players in implementing solutions
- **Education and research** - Mobilize expertise, share knowledge and develop know-how
- **Communication** - Explain the issues at stake, make people understand the urgent need for action and highlight solutions

Projects

- **Canadian Energy Outlook :** project describing and analyzing the transformations required in order to meet net-zero objectives in Canada
- Managing **peak electricity demand** and improving resilience in an increasingly electrified world
- Co-direct, with IESVic and the University of Calgary, the **Energy Modeling Hub**, a pan-Canadian organization that develops, maintains and makes available energy models, and brings together public decision-makers and the energy modeling community.

Biomass and carbon neutrality project

This project was led and conducted by the Institut de l'énergie Trottier with the support of the Transition Accelerator (TA).

The Institut de l'énergie Trottier

The IET was created in 2013 thanks to an exceptional donation from the Trottier Family Foundation to Polytechnique Montréal. Since then, it has been involved in every energy debate in the country.

At the source of major collective reflections, its team mobilizes knowledge, analyzes data, popularizes issues and recommends fair and effective plans, simultaneously contributing to academic research and training.

The Transition Accelerator

The Transition Accelerator is designed to support Canada's transition to a net zero future while solving societal challenges. The Accelerator works with innovative groups to create visions of what a socially and economically desirable net zero future will look like and build out transition pathways that will enable Canada to reach it.

The four-step approach of the Accelerator is to understand, codevelop, analyze and advance credible and compelling transition pathways capable of achieving societal and economic objectives, including driving the country towards net zero greenhouse gas emissions by 2050.

Funding

To support the mandate of Canada's Net-Zero Advisory Body related to research, this project was undertaken with the financial support of the Government of Canada. Funding was provided through the Environmental Damages Funds' Climate Action and Awareness Fund, administered by Environment and Climate Change Canada.
The Institut de l'énergie Trottier and the Transition Accelerator also contributed to this project.

This project was undertaken with the financial support of the Government of Canada.
Ce projet a été réalisé avec l'appui financier du gouvernement du Canada.

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kashika studio

Acknowledgements

Collaborators, external revisors and participants that contributed at different phases

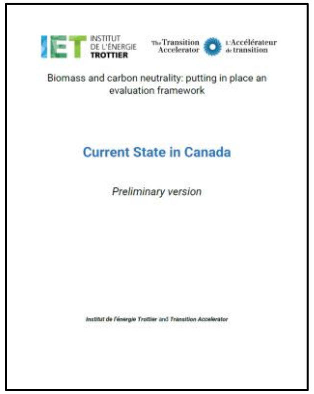
The Simpson Centre and University of New Brunswick helped organize workshops in Calgary and Fredericton, and the Pacific Institute for Climate Solutions helped moderating the discussion tables in Vancouver.

J. Harvey Consultant & Associés Inc., ESMIA Consultants and Joseph Lefèvre helped enrich the data analysis.

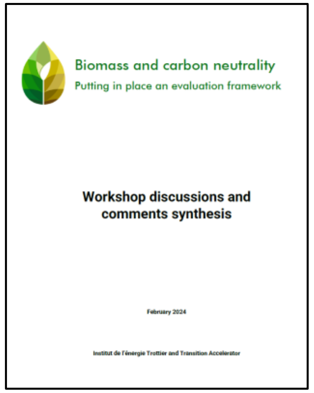
Several stakeholders and experts contributed to this project either by participating in discussions (during workshops, forum and in other meetings) or/and by reviewing the project reports and sharing their comments and suggestions for this project.

The list of persons who participated to the workshops or/and reviewed the reports are available in [the published documents.](#)

Project phases

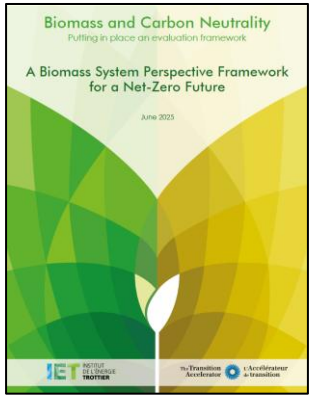


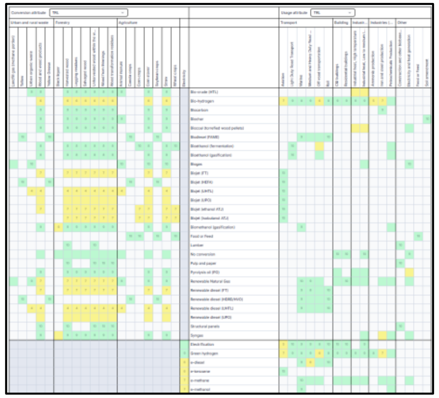
Preliminary version of the White Paper
'Current State in Canada'



Report of workshop discussions

Final version of the White Paper





- **Final report proposing an evaluation framework for biomass uses**
- **First version of a decision-support tool**

1st year | **2nd year**

Project launched

Regional Workshops
Montréal, QC
Fredericton, NB
Calgary, AB
Vancouver, BC
Toronto, ON

Midterm Forum
Ottawa, ON

All project reports are available here: https://iet.polymtl.ca/en/biomass-and-carbon-neutrality/results

What we'll talk about today

An overview on biomass in Canada's path to net zero

- Impact of biomass use in terms of climate change mitigation
- Biogenic emissions tracking in Canada's inventory
- Types of existing evaluation methods for biomass

Putting in place an evaluation framework

- Proposed approach
- The *Biomass System Perspective* decision-support tool
- Recommendations

Part 1: An overview on biomass in Canada’s path to net zero

The first part of the report is dedicated to present an overview of studies and methods used to analyze, track or evaluate biomass uses.

To develop an evaluation framework for biomass, we need to address the **factors that make bioenergy unique** among other types of renewable energy and **that are crucial to understanding the impact of choices** we make when developing new projects aimed at using these resources for bioenergy or non-energy purposes.

Impact of biomass use in terms of climate change mitigation

Although biomass use for bioenergy is often assumed to be carbon neutral, **biomass resources and their end-uses are diverse and disparate in terms of their environmental impact**.

Biomass use **can contribute to climate change mitigation** under different circumstances that **depend on many factors**, including:

- Biomass type as well as location of harvest and its fate in alternative scenario
- Types of bioproducts and their corresponding biomass conversion efficiency and their lifecycle emissions
- Types of fossil fuels and products that we intend to substitute in the end-use applications and their lifecycle emissions

Mitigation benefit = cumulative GHG emissions from biomass use **are lower** than from fossil alternatives on a certain timescale (*due to subsequent C sequestration in forest in the case of bioenergy*)

Mitigation benefits from biomass use occur **over a certain timescale**. To evaluate whether biomass use is providing mitigation benefits, the timescale considered must be defined.

See report sections 1.2 and 1.3

Tracking biogenic CO_2 in Canada's NIR

How are biogenic emissions accounted for in Canada's inventory and what is the current state of emissions?

- Removals and emissions are reported differently for forestry and agricultural biomass in national inventories.
- Biogenic CO_2 emissions from forest biomass combustion for bioenergy **are included** in Canada's national inventory report (NIR) in the LULUCF category.
- The assumption of carbon neutrality **in the inventory applies only to annual biomass**.

Biogenic CO_2 from combustion

For annual biomass (e.g., corn crops): **not reported**

For forest biomass (e.g., wood chips): **reported within the LULUCF sector**

Non-CO_2 biogenic emissions (CH_4 and N_2O)

Reported in energy and waste sectors

- The IPCC requires complete coverage of all IPCC sectors, including AFOLU and Energy, which together, include the emissions (CO_2 and other GHG) from **biomass used for energy purposes at the national level**.

Sources: Camia et al. 2021; IPCC n.d.; Liu et al. 2017

See report section 1.4

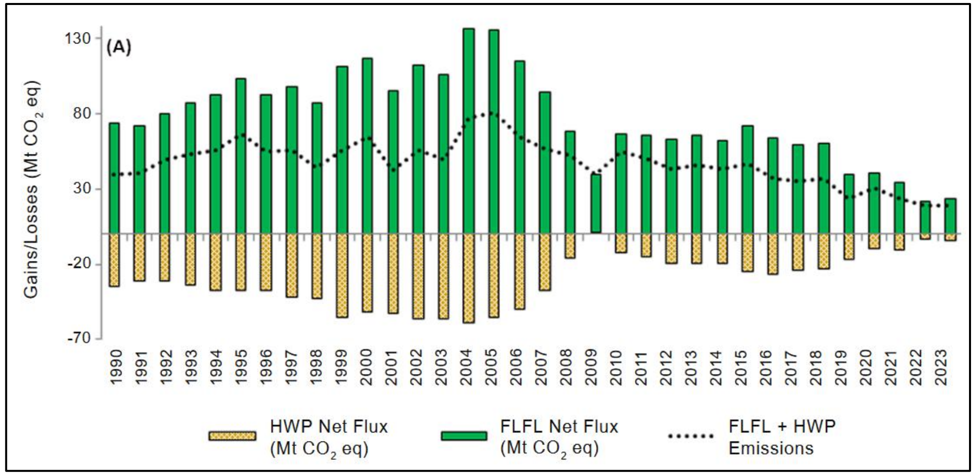
Tracking biogenic CO_2 in Canada's NIR

Managed forests

- The sum of removals, emissions and carbon transfers reported in the Forest Land and in the Harvested Wood Products (HWP) categories **represent the net annual flux** of carbon of the managed forests.
- If carbon removals in Canada's managed forests remained higher than its carbon emissions, including carbon emissions from combustion or decomposition of wood products in a given year, forests would be a carbon sink.
- However, in all the time series, forests were classified **as a carbon source**.

Sectoral category	**Net GHG Flux** ($Mt\ CO_2e$)							
	1990	**2005**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Forest land *(anthropogenic component)*	73	140	60	40	40	34	22	24
Harvested Wood Products	-38	-57	-24	-18	-10	-12	-4	-5.1
Cropland	5.5	-20	-20	-15	-13	-16	25	-22
Grassland	0	0	0	0	0	0	0	0
Wetlands	5.1	2.7	2.5	2.7	2.9	2.8	2.6	2.6
Settlements	4.8	4.7	5.4	5.3	5.3	5.5	5.2	5
LULUCF total *(reported)*	50	66	24	15	25	15	51	4
Natural disturbances in managed forests *(tracked but not reported)*	-120	12	250	160	2.7	290	87	1 100

Managed forests (FLFL + HWP)



FLFL: Forest Land Remaining Forest Land

Sources: Government of Canada 2025

See report section 1.4

Tracking biogenic CO_2 in Canada's NIR

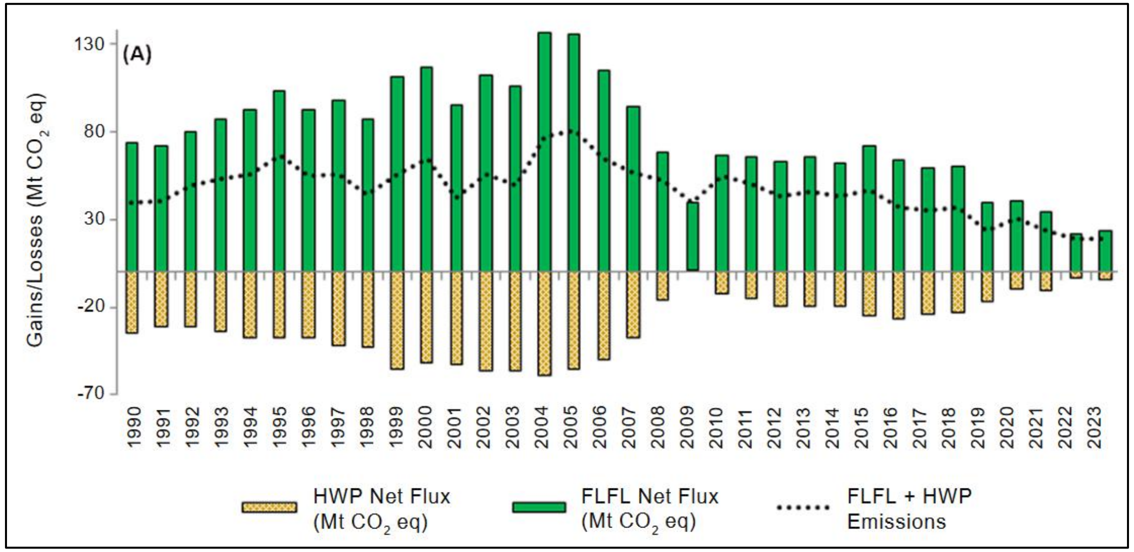
Managed forests

Emissions in the HWP category in 2023:

- 33% from long-lived wood products *(e.g. sawn wood used in construction that reaches the end of its useful life*)
- 25% from short-lived products *(e.g. pulp and paper)*
- 39% from bioenergy

Reporting in the HWP category now represents (since the 2025's NIR) the **difference between annual carbon inputs to the HWP pool** (as carbon gain) **and the annual emissions** originating from the disposal or from combustion of wood products.

Managed forests (FLFL + HWP)



Sources: Government of Canada 2025

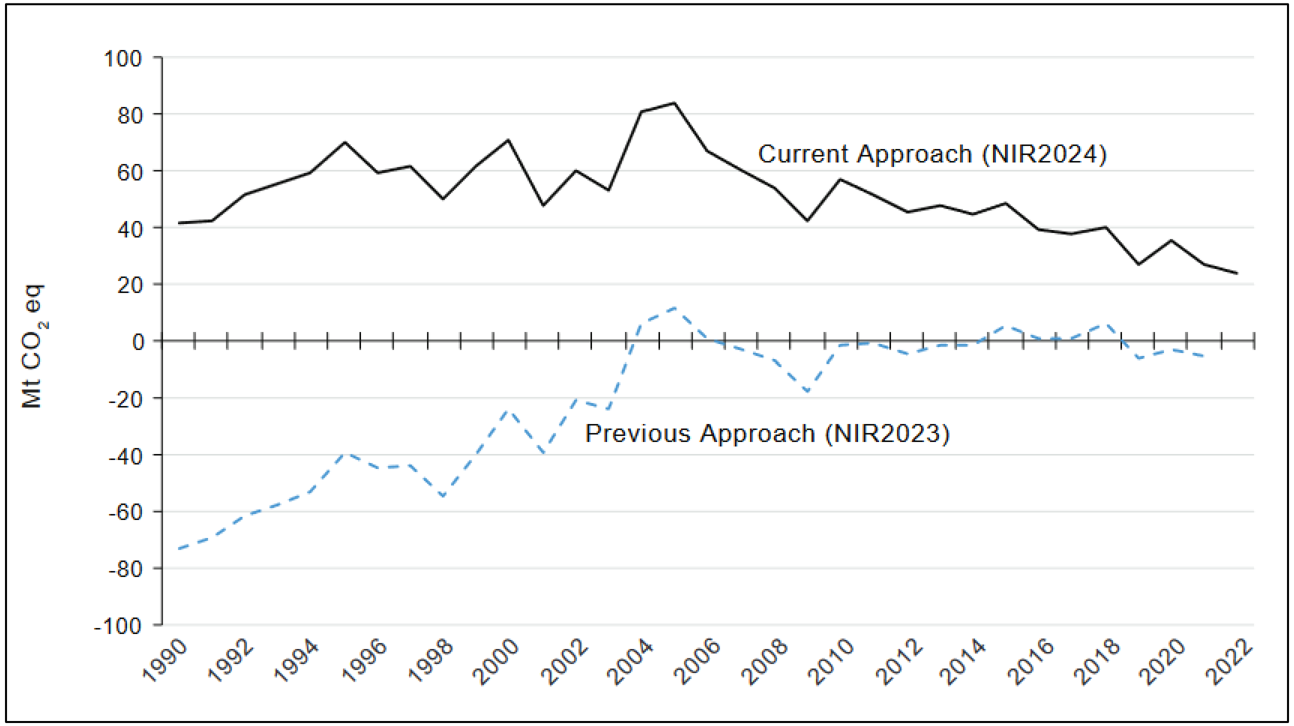
See report section 1.4

Tracking biogenic CO_2 in Canada's NIR

Revisions in Canada's NIR of 2024

- Recalculations were made in Canada's national inventory report of 2024 for the LULUCF sector, which had a significant impact on estimated emissions, mainly due to a review of the historical harvest areas.
- These corrections **shifted the LULUCF sector from a net carbon sink to a net carbon source** through the entire inventory time series.

Emissions of Managed Forests combining Forest Land and Harvested Wood Products (HWP) in Canada's NIR of 2024 compared to the previous approach



Sources: Government of Canada 2024

See report section 1.4

Tracking biogenic CO_2 in Canada's NIR

Revisions in Canada's NIR of 2025

Major revisions to Canada's reporting approach for the LULUCF sector were also made in the 2025 NIR.

- **Reporting in the Forest Land category**:

In the 2025 NIR: now includes the fluxes of carbon of wood products out of the forest ecosystem (as carbon loss) which is then transferred to the HWP pool (as carbon gain).

Before the 2025 NIR: it previously included only CO_2 removals from the atmosphere and the emissions from decomposition of biomass in the forest ecosystem.

- **Reporting in the HWP category**:

In the 2025 NIR: represents the difference between annual carbon inputs to the HWP pool (as carbon gain) and the annual emissions originating from the disposal or from combustion of wood products.

Before the 2025 NIR: it previously reported only the annual gross emissions from the disposal or from combustion of HWP

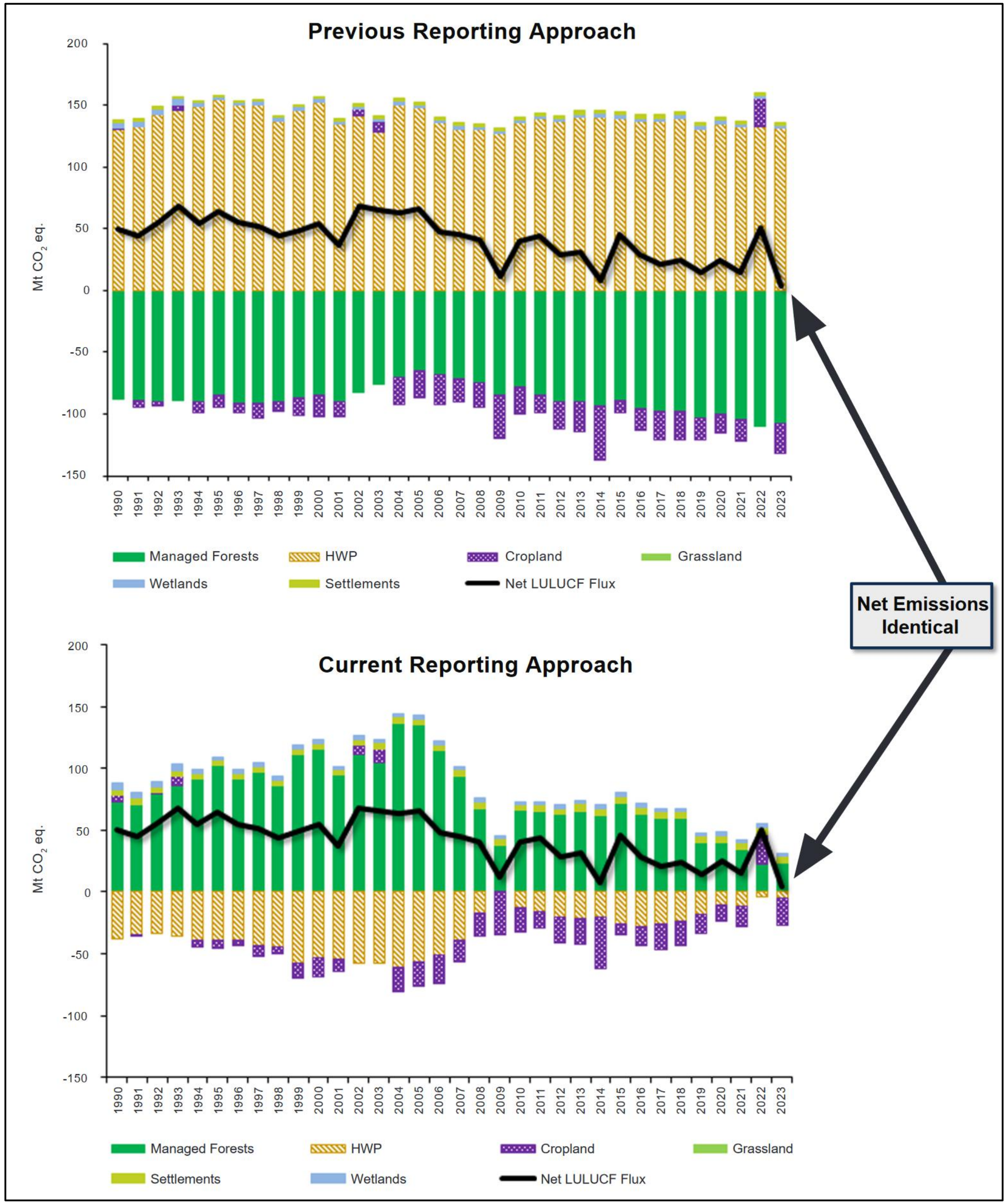
Sources: Government of Canada 2025

See report section 1.4

Tracking biogenic CO_2 in Canada's NIR

Revisions in Canada's NIR of 2025

- The changes flipped the Forest Land category from a net sink to a net source, **while they simultaneously** flipped the HWP category from a gross emission source to being reported as a net gain of carbon storage.
- Despite the significant changes done in the reporting categories, **the net emissions of the forest sector did not change* in the 2025 NIR**.
- The objective of these revisions according to the NIR, were to improve the comparability of Canada's HWP reporting with other countries, to better capture the immediate impact of harvest on carbon stocks and the important role of HWP as a global carbon store.



* Only, minor recalculations were made due to some methodological changes

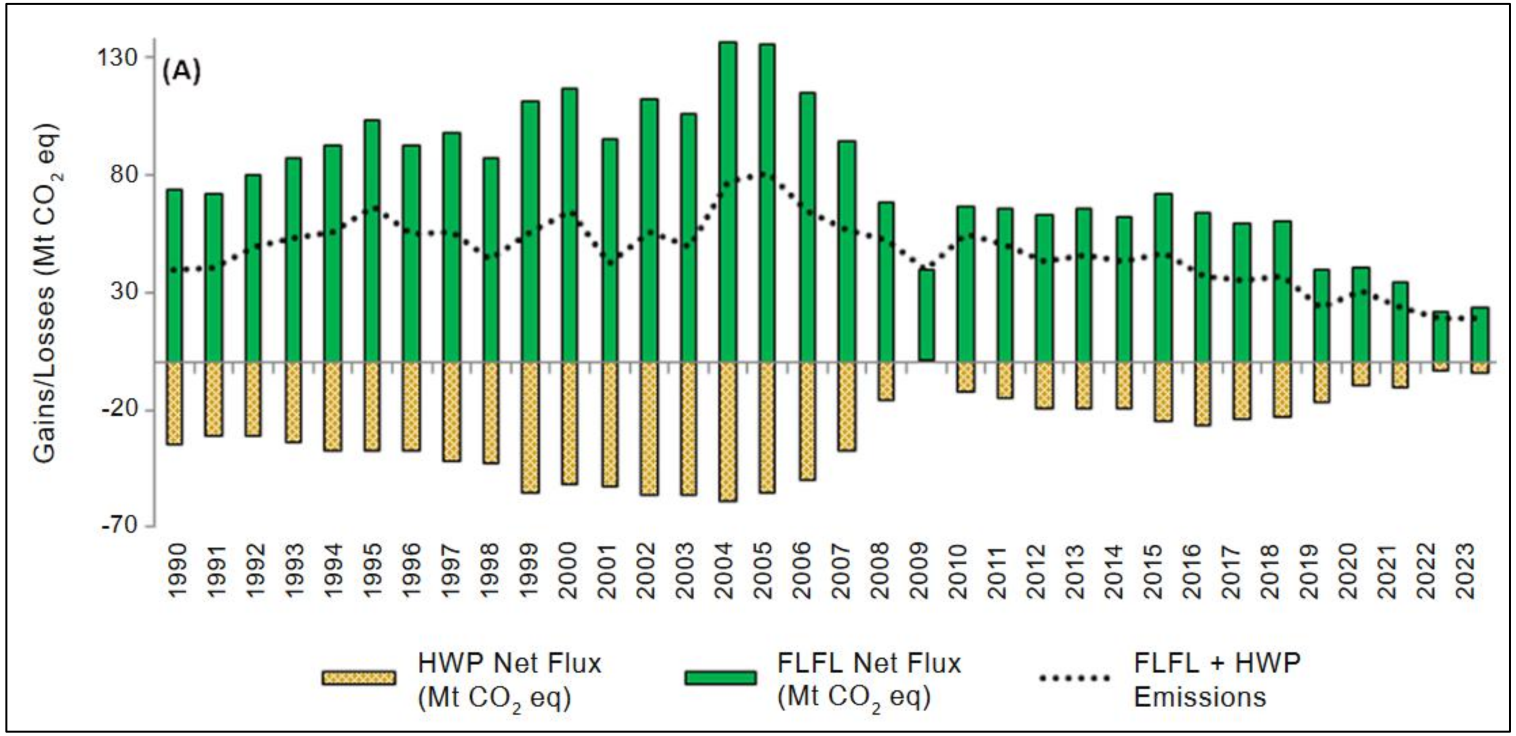
Sources: Government of Canada 2025

See report section 1.4

Tracking biogenic CO_2 in Canada's NIR

Canada's NIR of 2025

Managed forests (FLFL + HWP)



« Emissions and removals reported from the forest sector, without the natural disturbance component but also considering fluxes of carbon to the Harvested Wood Products category, **demonstrate that the Canadian Forest sector acts as a net source of carbon** transferred to the atmosphere and to the global waste stream **as a result of short- and long-term impacts of human management** ».

(Citation from Canada's NIR, Government of Canada, 2025)

Sources: Government of Canada 2025

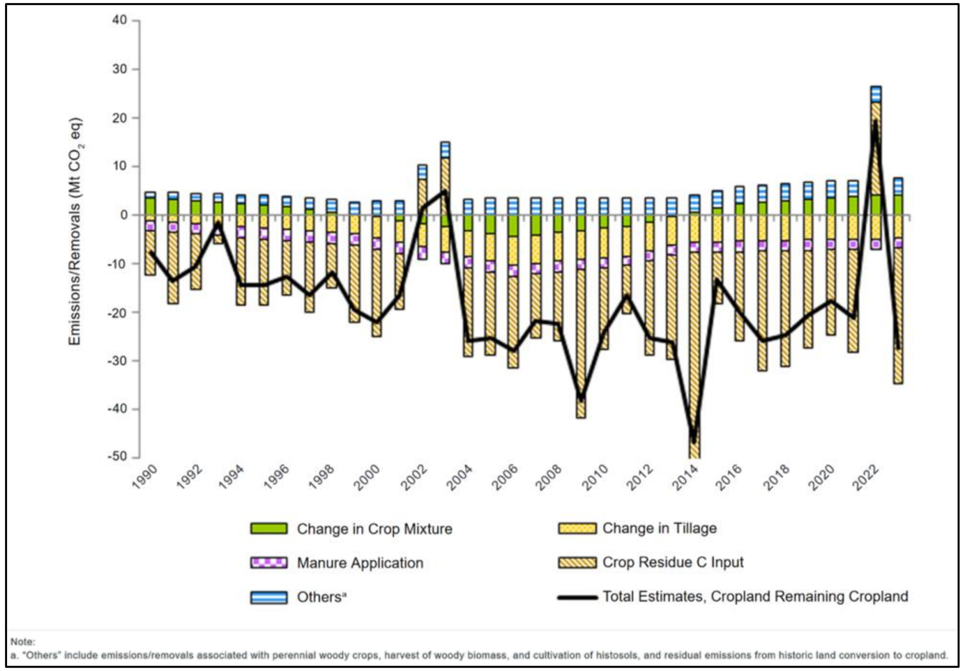
See report section 1.4

Tracking biogenic CO_2 in Canada's inventory

Croplands

- Emissions and removals are impacted by the input of organic C in mineral soils.
- Crop residues contribute to carbon removals in croplands through carbon input to agricultural soils. This contribution has the highest impact on emissions declared in this sector.
- In Canada's NIR, **croplands have been a net carbon sink in almost all the time series. However, exceptionally in 2022, they were a net source of emissions of 25 Mt**, which was associated with the 2021 drought in Western Canada (Government of Canada 2025).
- Weather variations and drought events have a huge impact on crop yields and carbon inputs to soils and, accordingly, on emissions from croplands.

Emissions reported in Canada's 2025 NIR for Croplands remaining Croplands



Sources: Government of Canada 2025

See report section 1.4

Methodology used for the LULUCF in national targets accounting

When tracking Canada's progress towards its national targets:

- An "accounting contribution" value is calculated for the LULUCF sector and then added to Canada's total net GHG emissions.
- The "accounting contribution" of LULUCF **is not equivalent** to the total emissions of the LULUCF sector reported in the national inventory report.

To estimate the accounting contribution from LULUCF:

- **A "reference level" accounting methodology is used for managed forests**: emissions reductions from managed forests are calculated as the difference between forest emissions in the reporting year and the estimated emissions for that same year that would occur if past management practices continued business-as-usual.
- **A "net-net" approach is used for the rest of the LULUCF categories:** comparing emissions of the reporting year to a base year (2005).

Therefore, in 2022, the accounting contribution from LULUCF was +12 Mt CO_2e while the net emissions in LULUCF sector reported in the national inventory were +51 Mt CO_2e.

See report section 1.4

Methodology used for the LULUCF in national targets accounting

- In 2022, total GHG emissions of Canada (excluding LULUCF) were 708 Mt CO_2e. By adding the LULUCF accounting contribution (+12 Mt for 2022), Canada's GHG emissions were 720 Mt CO_2e.
- The **"accounting contribution" from LULUCF is expected to remain a credit of around -30 Mt** CO_2e to Canada's GHG emissions until 2040.
- As for **the net emissions of the LULUCF sector**, Canada's most recent projections (published in February 2025) show a decrease in emissions to reach negative emissions starting from 2023.

Historical and projected LULUCF net GHG flux and accounting contribution

LULUCF sector	Historical GHG flux (Mt CO2e)			Projected GHG flux (Mt CO2e)				
	2021	2022	2023	2023	2025	2030	2035	2040
Net GHG flux	**+14** [a, b, c]	**+51** [a, b, c]	**+4.2** [a]	**-12** [c]	**-4** [b, c]	**-18** [b, c]	**-25** [b, c]	**-23** [b, c]
Accounting contribution	**-29** [b, c]	**+12** [b, c]	NA	**-44** [c]	**-29** [b, c]	**-28** [b, c]	**-31** [b, c]	**-30** [b, c]

[a] Published in Canada's national inventory report of 2025
[b] Published in Canada's first Biennial Transparency Report on 30 December 2024
[c] Datasets from Canada's current projections published in February 2025 on the website of ECCC
[d] Some values differ by 1 or 2 Mt CO_2e from one reference to another. For clarity of information presented in the table, only one value is presented.

Climate change impact on C stocks

Climate change is already affecting biogenic carbon stocks in Canada

CBC

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Saskatchewan

Sask. premier declares provincial state of emergency

'Unlike anything we have faced in quite some time, if not ever': Premier Scott Moe

Laura Sciarpelletti, Hannah Spray · CBC News · Posted: May 29, 2025 1:59 AM EDT | Last Updated: May 29

A wildfire burns Wednesday at Besnard Lake in Saskatchewan. (Submitted by Trevor Phenix)

Manitoba declares state of emergency as wildfires rage, forcing evacuations

TEMUR DURRANI >
INCLUDES CORRECTION
WINNIPEG
PUBLISHED MAY 28, 2025
UPDATED MAY 30, 2025

Smoke rises from a wildfire in Flin Flon, Man., on May 27, 2025.
MANITOBA GOVERNMENT/REUTERS

CBC

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Science

This could be Canada's 2nd-worst wildfire season

Fire danger greatest in southern B.C. in July, according to federal officials

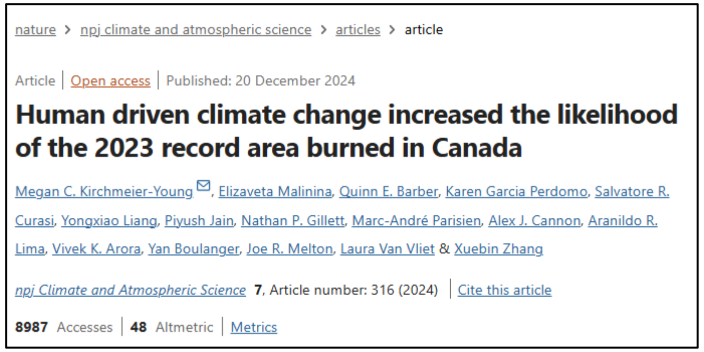
Nick Murray · The Canadian Press · Posted: Jun 12, 2025 2:43 PM EDT | Last Updated: June 12

Smoke rises from the Summit Lake wildfire, west of Fort Nelson, B.C., on June 3. Federal officials say this season is on track to become Canada's second-worst wildfire season. (BC Wildfire/Reuters)

Sources:
https://www.cbc.ca/news/canada/saskatchewan/saskatchewan-first-nations-wildfires-state-of-emergency-1.7546571
https://www.theglobeandmail.com/canada/article-manitoba-declares-state-of-emergency-as-wildfires-rage-forcing/
https://www.cbc.ca/news/science/fire-season-2025-1.7559565

Climate change impact on C stocks

- Canada's 2023 fire season was extreme compared to all other fire seasons in its recent history.
- From May to July 2023, wildfires burned 15 million hectares, compared to a nationwide annual average of 2.5 million hectares.
- Researchers showed that climate change significantly **increased the likelihood** of the long fire season and the large area burned in most regions of Canada in 2023.
- A study on the 2023 fire season in Eastern Canada showed that **peak fire weather** like that experienced in 2023 is **at least twice as likely to occur** today compared to under preindustrial climate.
- The **intensity of fires** has increased by some 20% due to human-induced climate change. In Quebec, climate change led to fires being 50% more intense at the end of July 2023 relative to the pre-industrial climate.


nature > npj climate and atmospheric science > articles > article

Article | Open access | Published: 20 December 2024

Human driven climate change increased the likelihood of the 2023 record area burned in Canada

Megan C. Kirchmeier-Young, Elizaveta Malinina, Quinn E. Barber, Karen Garcia Perdomo, Salvatore R. Curasi, Yongxiao Liang, Piyush Jain, Nathan P. Gillett, Marc-André Parisien, Alex J. Cannon, Aranildo R. Lima, Vivek K. Arora, Yan Boulanger, Joe R. Melton, Laura Van Vliet & Xuebin Zhang

npj Climate and Atmospheric Science **7**, Article number: 316 (2024) | Cite this article

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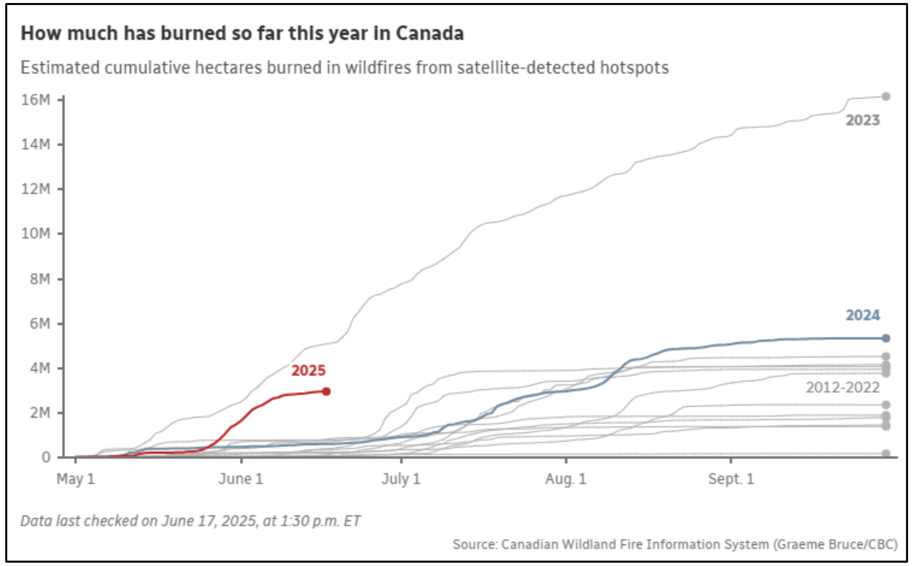


Source: https://www.cbc.ca/news/science/fire-season-2025-1.7559565

Sources: Barnes, C. et al. 2023. Climate change more than doubled the likelihood of extreme fire weather conditions in Eastern Canada. Imperial London College pages 1-26.
Kirchmeier-Young, M.C., Malinina, E., Barber, Q.E. *et al.* Human driven climate change increased the likelihood of the 2023 record area burned in Canada. *npj Clim Atmos Sci* **7**, 316 (2024).
https://www.worldweatherattribution.org/climate-change-more-than-doubled-the-likelihood-of-extreme-fire-weather-conditions-in-eastern-canada/

Climate change impact on C stocks

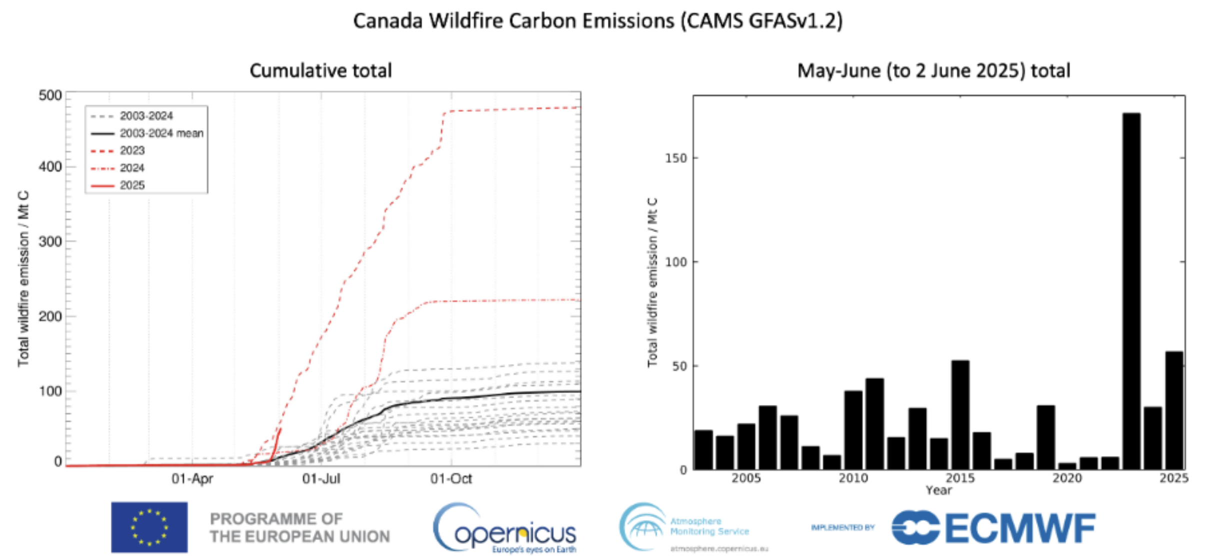
In 2023: total emissions **from natural disturbances* in managed forests reached a total of 1100 Mt CO_2e**, around 150% higher than the total GHG emissions in Canada.

In 2025: according to data from the CAMS Global Fire Assimilation System (GFAS), the total estimated fire emissions for Canada **are second only to 2023 up until 2 June 2025**.

	Net GHG Flux (Mt CO_2e)							
	1990	2005	2018	2019	2020	2021	2022	2023
LULUCF total *(reported)*	50	66	24	15	25	15	51	4
Natural disturbances *(tracked but not reported)*	-120	12	250	160	2.7	290	87	**1 100**

Note * Natural disturbances component include lands impacted by both Wildfire and insect disturbance.

Source: Government of Canada 2025



CAMS GFASv1.2 daily total fire radiative power (left) in May, comparing 2025 (in red) with the 2003-2024 mean (in grey) and the years 2023 and 2024 (dashed and dot-dashed red lines) and total estimated carbon emissions (right) for Canada in May. The year 2025 has seen the second highest emissions up to 1 June in the dataset going back to 2003. Source: CAMS

Source: https://atmosphere.copernicus.eu/cams-tracks-smoke-intense-canadian-wildfires-reaching-europe

See report section 1.5

Current evaluation methods for biomass

Researchers, project developers, policymakers and international standards committees have developed various methods to evaluate biomass uses for bioenergy or biomaterials, depending on the scope of the study and the objective of the evaluation.

In the final report, the main objective was to explore methods that are currently deployed to assess biomass use in a context of Canada's transition to net zero.

We thus focused on methods that included in the evaluation the impact on GHG emissions.

Existing methods are categorized as follows:

- Sustainability criteria and standards;
- Climate mitigation benefit assessment: Project scale vs regional scale;
- Decision making support tools: Resource focused vs End-use focused.

See report section 2

Climate mitigation benefit assessment

Project scale vs regional scale

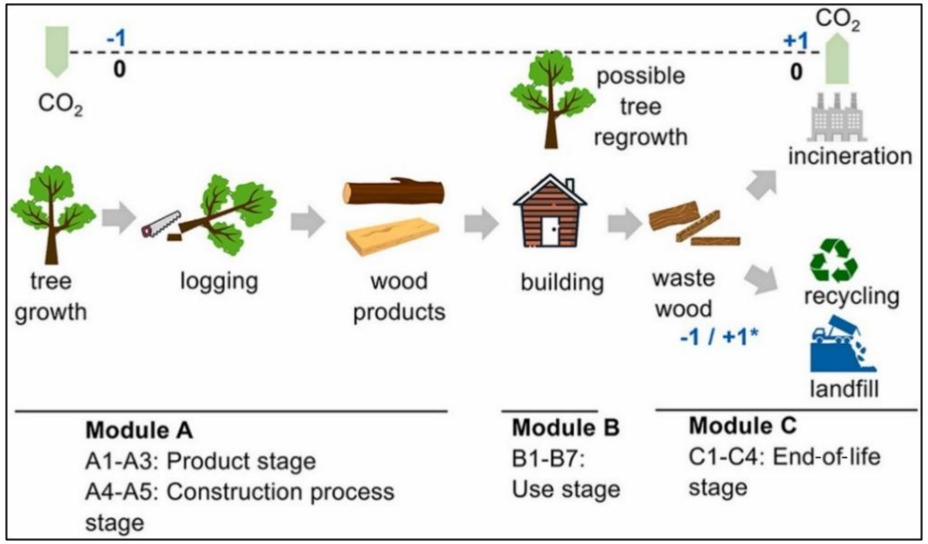
See report section 2

Climate mitigation benefit assessment

On a project scale

- To evaluate the benefits of a biomass project on GHG emissions, **life-cycle assessments (LCA)** are often conducted to determine these emissions at all stages of the life cycle of a bioproduct.
- Bioproducts can be biochemicals, biomaterials or biofuels.
- In the case of biomass use for biomaterials such as wood use in buildings, LCA can be conducted for a certain product (e.g., a mass timber floor panel) or for an entire building, depending on the scope and objective of the evaluation.
- Biogenic CO_2 can be either included or excluded in LCA assessments of bioproducts depending on the objective and the scope of the analysis.

Life cycle stages used for a wood building assessment



Source: Ouellet-Plamondon et al. 2023

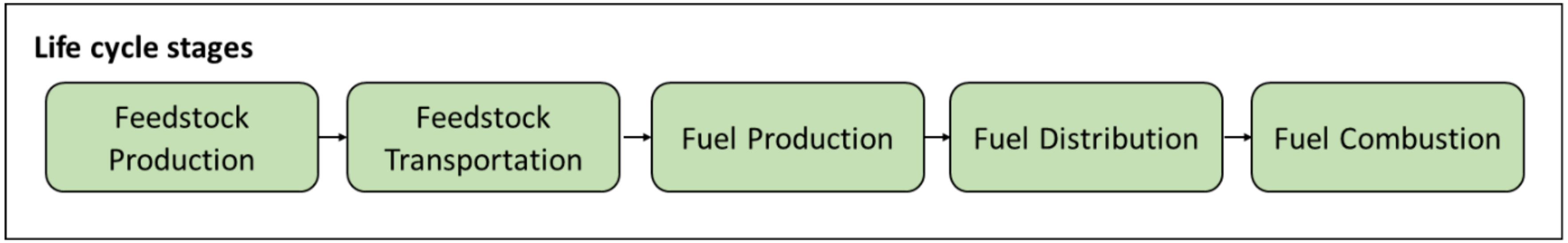
See report section 2.2

Climate mitigation benefit assessment

On a project scale

- The carbon intensity (CI) of the biofuel produced is also determined through LCA methodology.
- Different models for CI calculations have been developed in Canada and abroad (e.g., Fuel LCA Model used in Canada to determine the CI of fuels for GHG policies and programs).
- The purpose of CI values is to quantify all emissions released during the life cycle of the fuel produced, from feedstock preparation and transport to combustion.
- CI values are specific to each project.
- LCA models that are used **for biofuel CI calculations in Canada do not account for biogenic CO_2 emitted by the combustion of biofuels** in order to be consistent with the Government of Canada's policy on biogenic carbon and the guidelines of the national GHG inventories.

Life cycle stages used for biofuels



Source: ECCC 2024

See report section 2.2

Climate mitigation benefit assessment

On a project scale

- By determining the life cycle GHG emissions (carbon intensity) of biofuels or biomaterials, it is then possible to estimate **the relative GHG savings** that would occur if using these bioproducts to substitute higher carbon intensive products and fossil fuels.

Example of environmental benefits published for bioenergy projects

Bioenergy projects in Canada	Environmental benefit as announced
Biomethanol project by Varennes Carbon Recycling (QC) *(project was suspended in 2025)*	Carbon intensity of biofuel not mentioned. Yearly GHG emissions reductions of 170 kt CO_2e with a yearly production of 125 million litres of biofuels.
RNG project from agricultural waste by Nature Energy (QC)	Carbon intensity of biofuel not mentioned. Yearly GHG emissions reductions of 60 kt CO_2e with a yearly production of 20 million cubic meters RNG.
RNG project by G4 Insights (BC) *(produced from wood)*	GHG emissions reductions of 712.8 kt CO_2 over the project's design life. It is assumed to be used in transport as compressed natural gas (CNG). Carbon intensity of produced RNG: 14.3 g CO_2/MJ, which is compared to a carbon intensity of 95.86 gCO_2/MJ of gasoline.

Sources: Énergir Développement Inc. 2025; Enerkem 2025; G4 Insights Inc. 2015

- The approved CI of biomass projects under the CFR were published in 2024 for organizations that agreed to be included in the publication. Among the published CI data, a lot of information (e.g., name of the installation, type of boundaries used, value of the approved CI) was noted as confidential in the publication, thus constituting a barrier for tracking the CI of existing and new projects in Canada.

See report section 2.2

Climate mitigation benefit assessment

On a project scale

Limitations in the context of net zero transition

- Using CI values in GHG reduction programs and policies favours the production of bioproducts with lower fossil GHG emissions in the supply chain.
- There are limits to the CI values currently used (e.g., for determining whether local resources are used efficiently and considering the emissions of biogenic CO_2 from biomass combustion).
- Additional information is needed to estimate the full impact on emissions of developing a new project that aims to use biomass resources.

See report section 2.2

Climate mitigation benefit assessment

On a regional scale

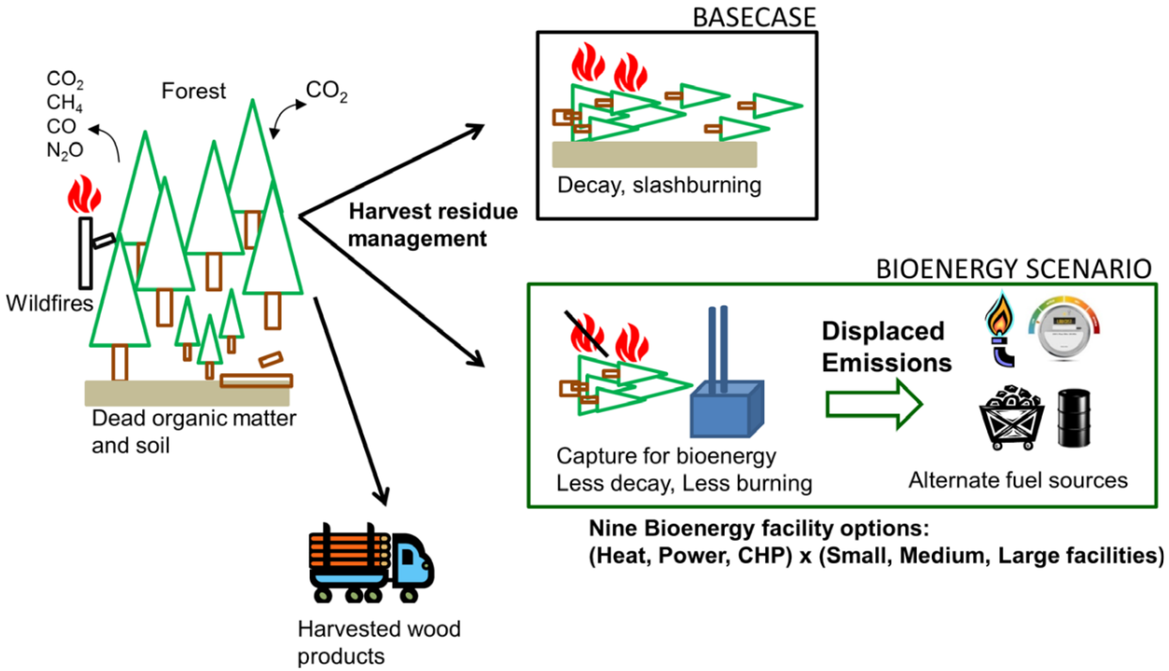
To evaluate the climate change mitigation potential of using biomass for bioenergy or other uses on a national or regional scale, many studies conducted for the forest sector used a "system approach" to quantify net emissions relative to a forward-looking baseline **and by including biogenic CO_2 emissions**.

More specifically, this approach combines the emissions and removals from three system components described below **to determine whether biomass use has a climate mitigation benefit over a certain timescale**.

(1) **Forest ecosystems:** includes all emissions and removals in the forest ecosystem (e.g., from tree growth, residues decay).

(2) **Harvested Wood Products:** includes biogenic emissions from combustion or decay from all harvested wood that is sent to markets as wood products, bioenergy or residual biomass.

(3) **Displaced emissions:** includes avoided GHG emissions from the substitution of fossil fuels by bioproducts.



See report section 2.2

Source: Smyth, C et al. 2017. "Climate Change Mitigation Potential of Local Use of Harvest Residues for Bioenergy in Canada." GCB Bioenergy 9(4):817–32.

Climate mitigation benefit assessment

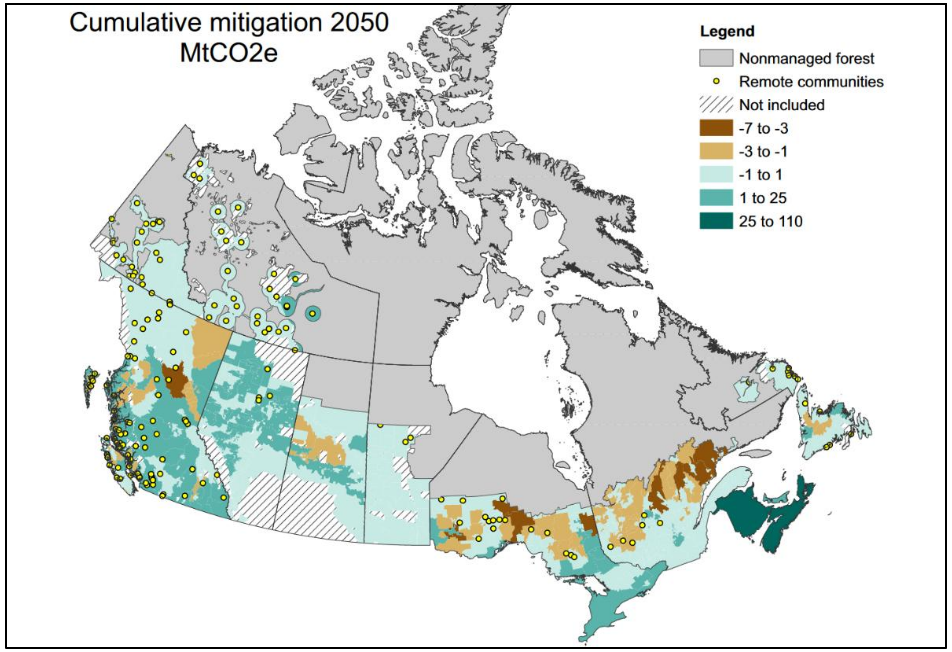
On a regional scale

Examples of studies that applied a similar methodology for analysis on a national, provincial or local level are presented in the report.

Main takeaways from regional scale studies

- It is possible to obtain **either positive or negative impact** on climate mitigation potential by using biomass resources for different bioenergy and bioproduct scenarios.
- Climate mitigation benefit is determined **for a certain timescale** (e.g., annual or cumulative until 2050).
- Obtaining a positive or negative climate mitigation impact from bioenergy production was found to be **location dependent** across Canada, **even when using the same types of biomass that are considered "residues"**.
- Results **depend on many factors** (e.g., landscape considered, current energy mix used, quantity of residues used, types of wood products sent to market).

Average cumulative climate change mitigation potential of using logging residues for bioenergy in Canada from 2017 to 2050



Source: Smyth, C et al. 2017. "Climate Change Mitigation Potential of Local Use of Harvest Residues for Bioenergy in Canada." GCB Bioenergy 9(4):817–32.

See report section 2.2.2

Part 2: Putting in place an evaluation framework

Main observations

- Resource-focused or end-use focused evaluation approaches

No decision-support tool with a **systemic view that integrates challenges and opportunities from both the supply and the demand perspective** is currently available.

- Multi-sectoral impact and interdependency of biomass industries

The climate mitigation benefit of biomass **depends on the decisions made at each step of this value chain**, starting with ecosystem management and biomass harvesting, through to conversion processes and disposal.

- Project and system-level perspectives

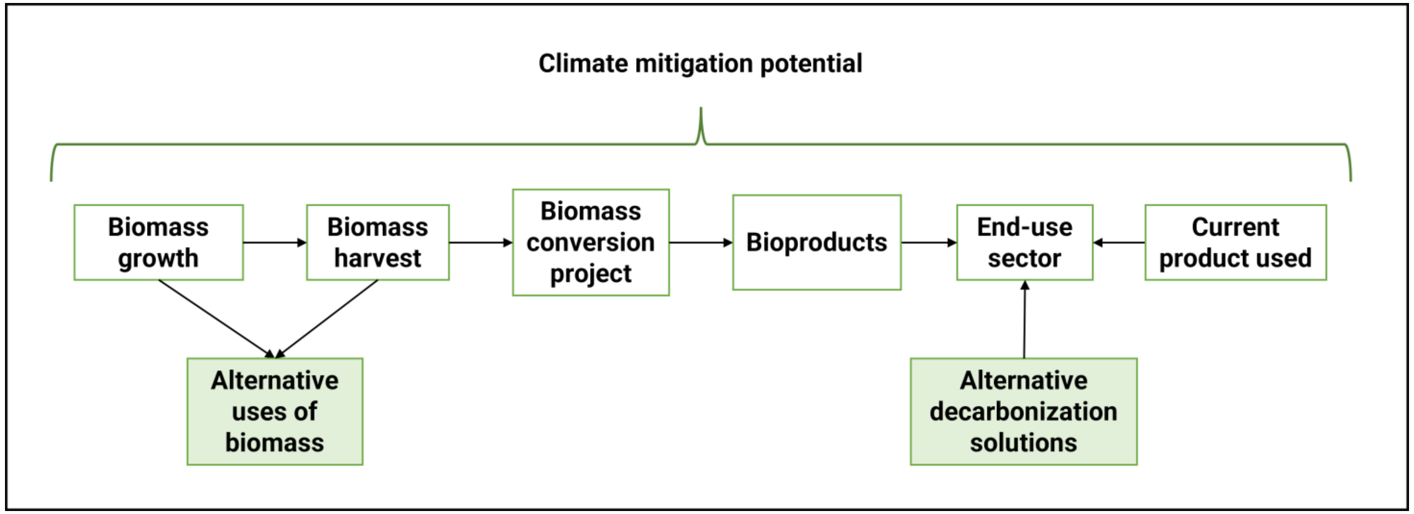
A system-level evaluation would allow for the consideration of a fate other than the proposed bioproduct for the biomass resource and alternative solutions for decarbonizing the end-use for which the bioproduct was intended. **Adopting such a biomass system perspective shifts the focus from fuel decarbonization to end-use decarbonization.**

Concept of the proposed framework

In order to evaluate a project aimed at using biomass resources for energy or non-energy purposes in a context of transition to net zero, the following three questions need to be taken into consideration:

1. What are the **alternative uses** for the available resources and the trade-offs for the project?
2. What is the project's contribution to end-use sector decarbonization and how does it compare to **alternative solutions**?
3. What is the project's impact on **climate change mitigation**?

To answer these questions, **indicators are needed from both the supply and the demand side** in order to make an informed decision on the best way to allocate biomass resources to different projects in a net-zero future.



Concept of the proposed framework

Identifying and comparing alternatives

On the supply side, alternatives to the proposed project for biomass use need to be identified.

These alternatives can be business as usual (e.g., leave residues in forest, dispose in landfills, use for non-energetic purposes, etc.) or an alternative conversion project. Viable alternatives should be selected based on the local context since biomass availability and conditions necessary for project development differ from region to region.

On the end-use/demand side, alternative decarbonization solutions must be identified for the sector under consideration. The benefits of the bioproduct must be compared not only to the fossil fuel it would displace, but also to the alternative choices that are compatible with a net-zero future.

After identifying relevant alternatives for biomass use and end-use sector decarbonization, the impact of these different choices must be compared, based on a variety of environmental, economic and social indicators.

Concept of the proposed framework

Impact on climate mitigation potential

Evaluating the impact of a new biomass conversion project on climate change mitigation cannot be straightforward because of the dynamics of biogenic carbon.

The methodology researchers use to evaluate the impact of various biomass uses depends on the scale of the analysis (project vs regional).

For comparison purposes, various indicators can be used to identify projects that could potentially lead to a better carbon balance.

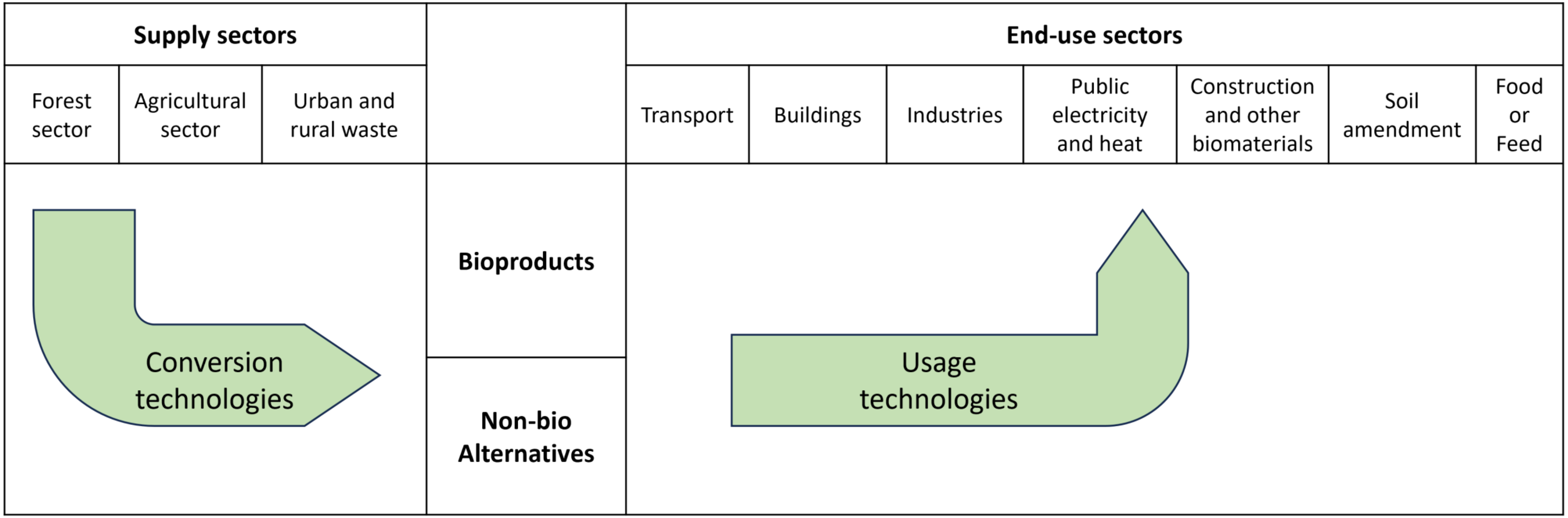
For example, by having a higher conversion efficiency, by substituting higher carbon intensive fossil fuels, or by storing biogenic carbon in products for a longer period (or permanent storage).

The Biomass System Perspective decision support tool

The concept of the BSP tool

The BSP decision support tool was designed by integrating biomass sectors that produce (supply side) or transform biomass feedstocks for energy and non-energy uses (end-use side).

This integrative structure enables the identification of potential competition or opportunities for biomass use, from the harvest of biomass feedstocks to the end-use of bioproducts in different sectors.



The Biomass System Perspective decision support tool

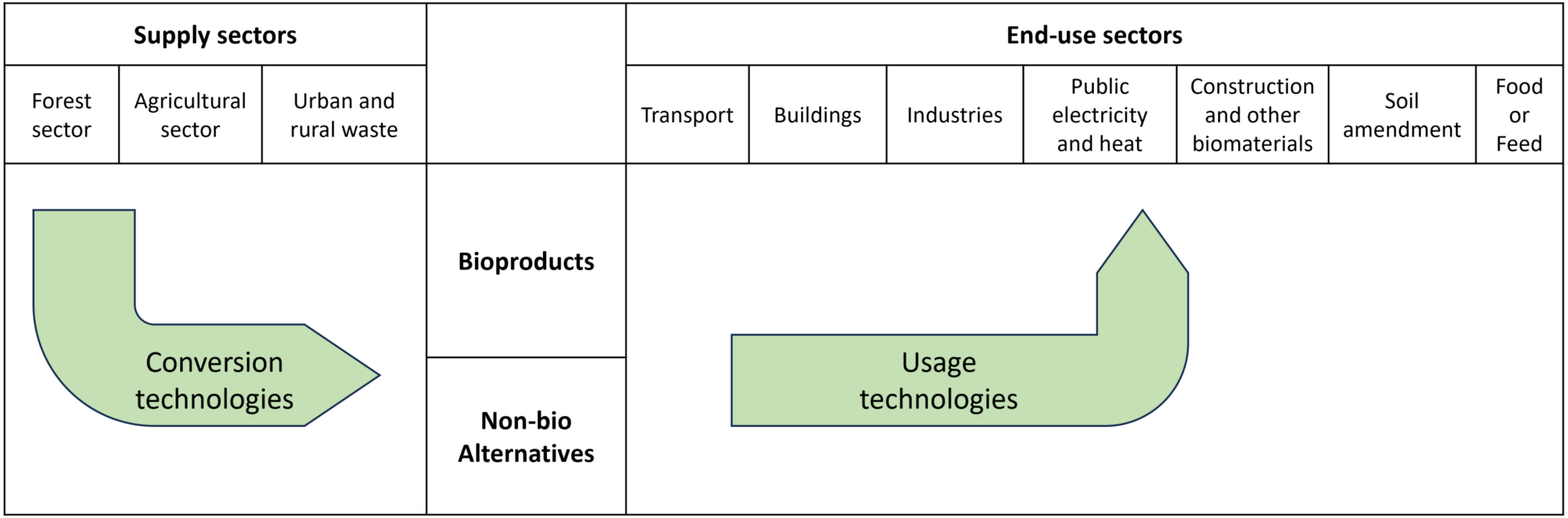
The concept of the BSP tool

More specifically, the BSP tool can be used to:

(1) Identify possible uses of various biomass resources,

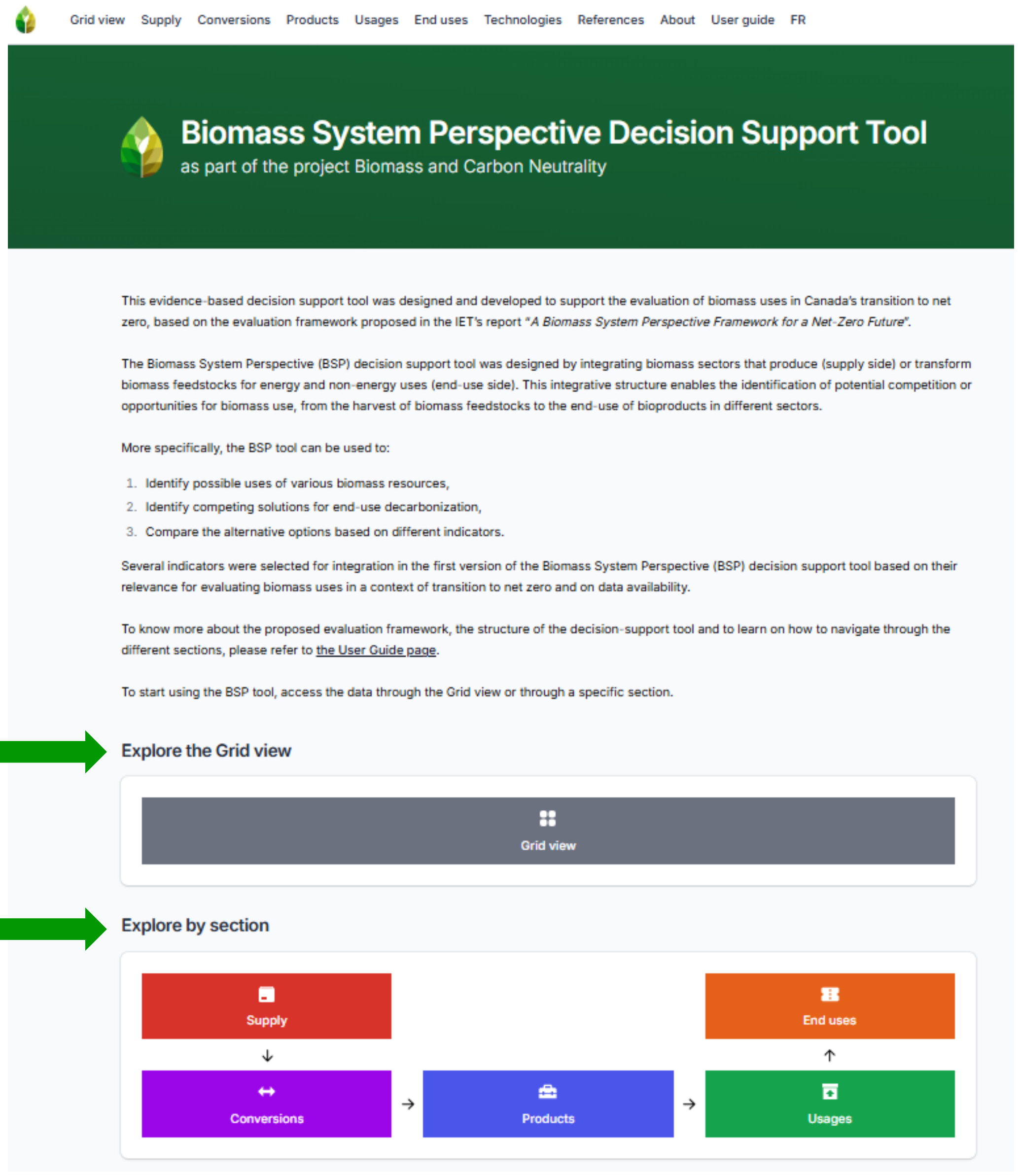
(2) Identify competing solutions for end-use decarbonization,

(3) Compare the alternative options based on different indicators (e.g., efficiency, carbon intensity, etc.).



The Biomass System Perspective decision support tool

- A first version of the Biomass System Perspective (BSP) decision-support tool was developed based on the proposed approach for an evaluation framework.
- The BSP tool is developed to support the evaluations of biomass uses in Canada.
- This tool is publicly available and can serve as a common basis for evidence-based project evaluations.
- Includes a Grid view, and specific views by section (supply, conversion, products, usages, end-uses).



The Biomass System Perspective decision support tool

Indicators

- Several indicators were selected for integration in the first version of the BSP decision support tool based on their relevance for evaluating biomass uses in a context of transition to net zero and on data availability.
- Detailed description of the indicators is available in the report and in the User Guide.
- During this project, regional workshops and a national forum were organized to bring together stakeholders and experts from academia, governments, Indigenous communities and industrial sectors to discuss elements that need to be considered when evaluating biomass uses. The workshops synthesis report sets out all the elements the participants proposed and discussed during the regional workshops.
- Indicators that were not covered in the scope of this project, such as economic indicators tied to the cost of resources and the cost of fuel production, can be further integrated to the tool in future work.

The Grid view

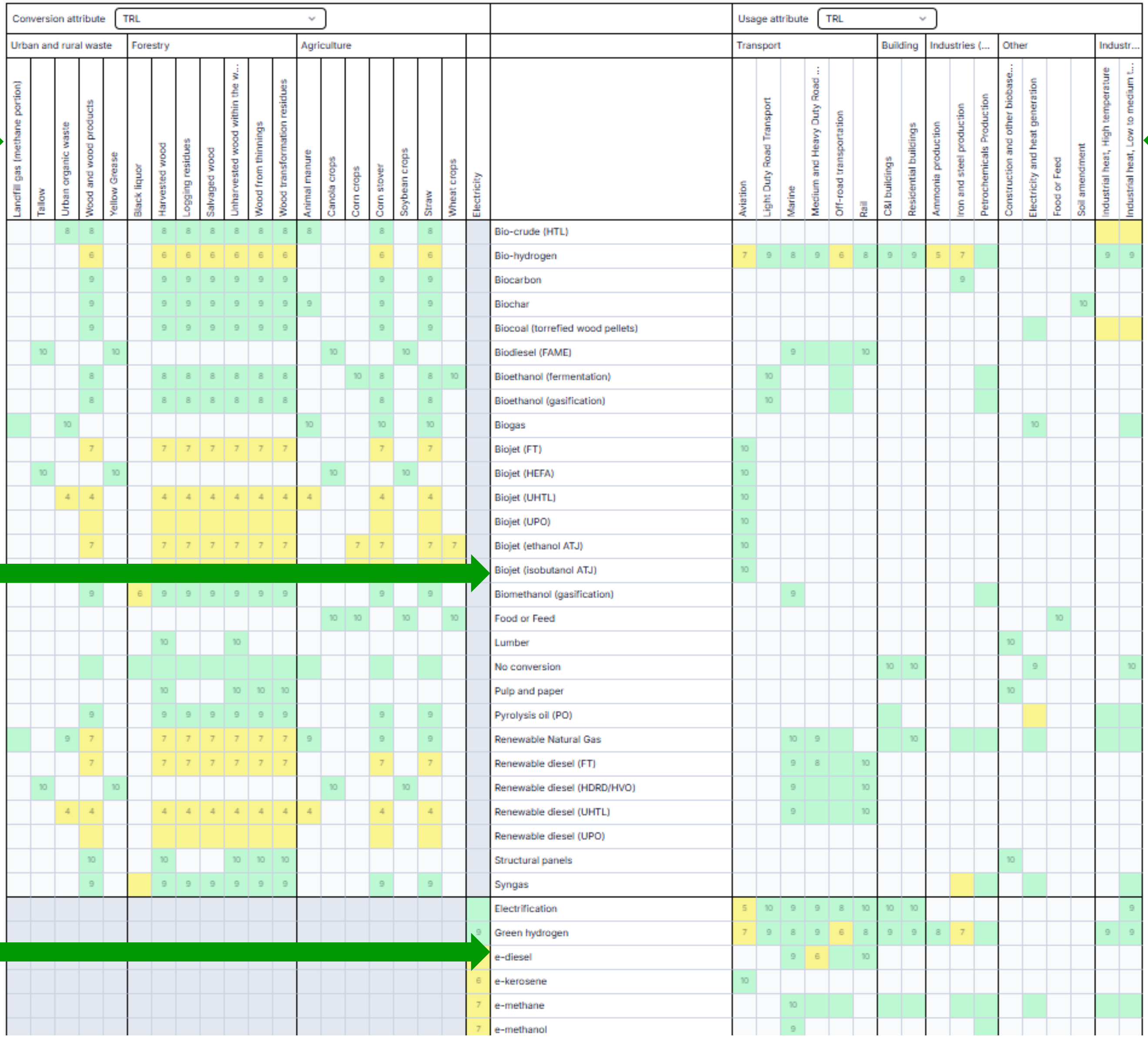
Supply

Supply

Bioproducts

Products

Non-bio alternatives



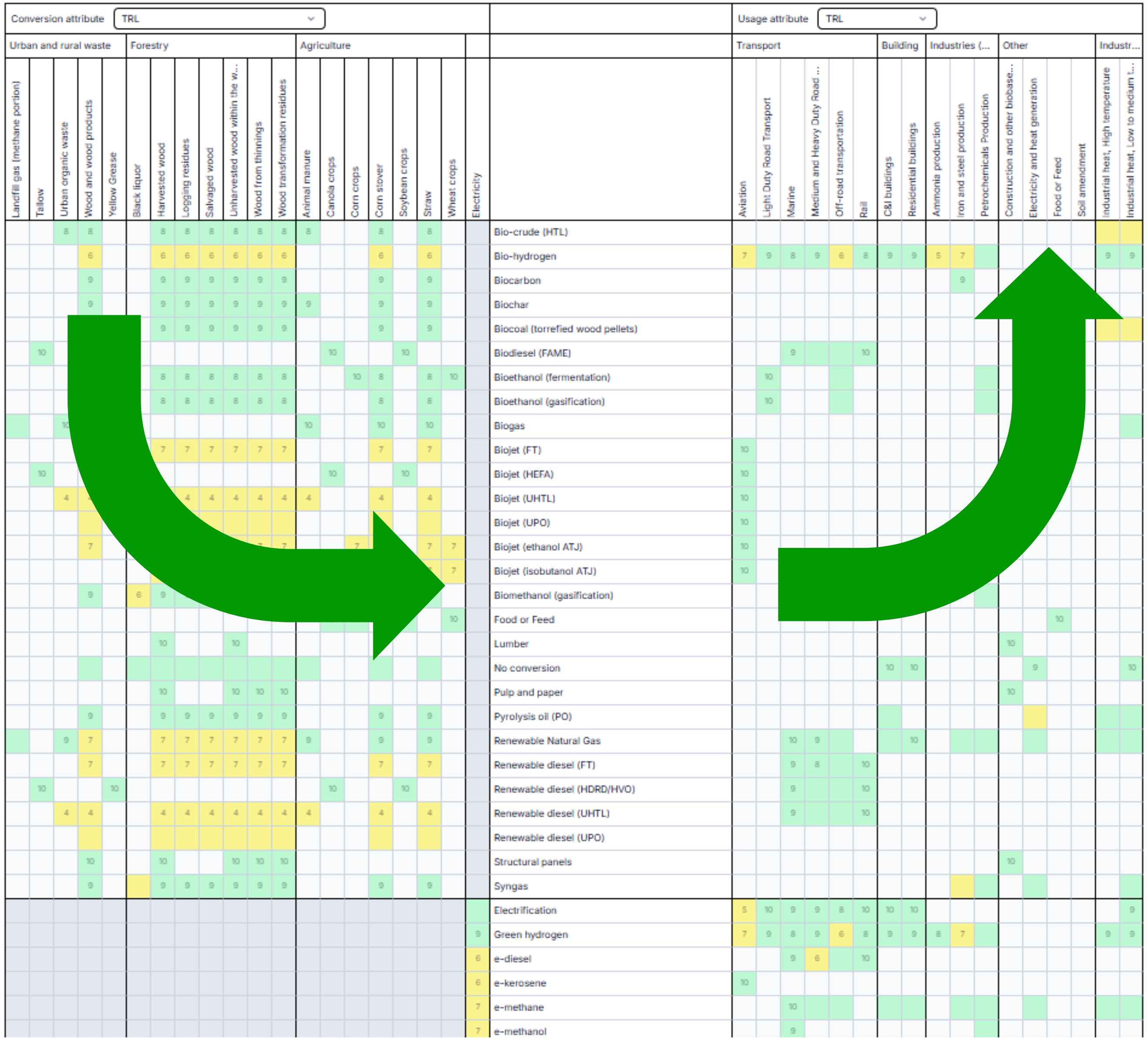
End-uses

End uses

The Grid view

Conversions

Conversions



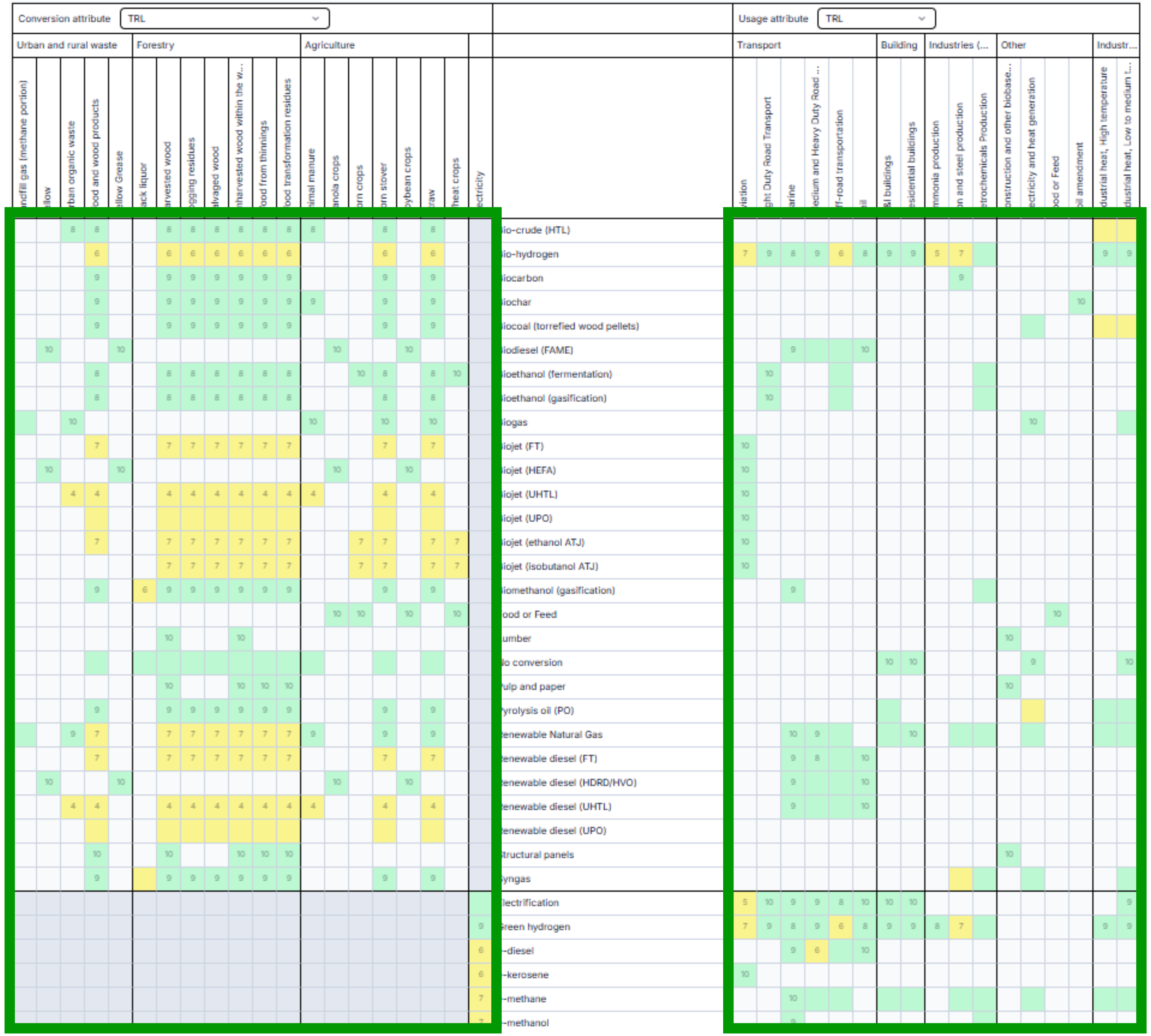
Usages

Usages

The Grid view

Conversion technologies

(e.g., anaerobic digestion, gasification, pyrolysis)

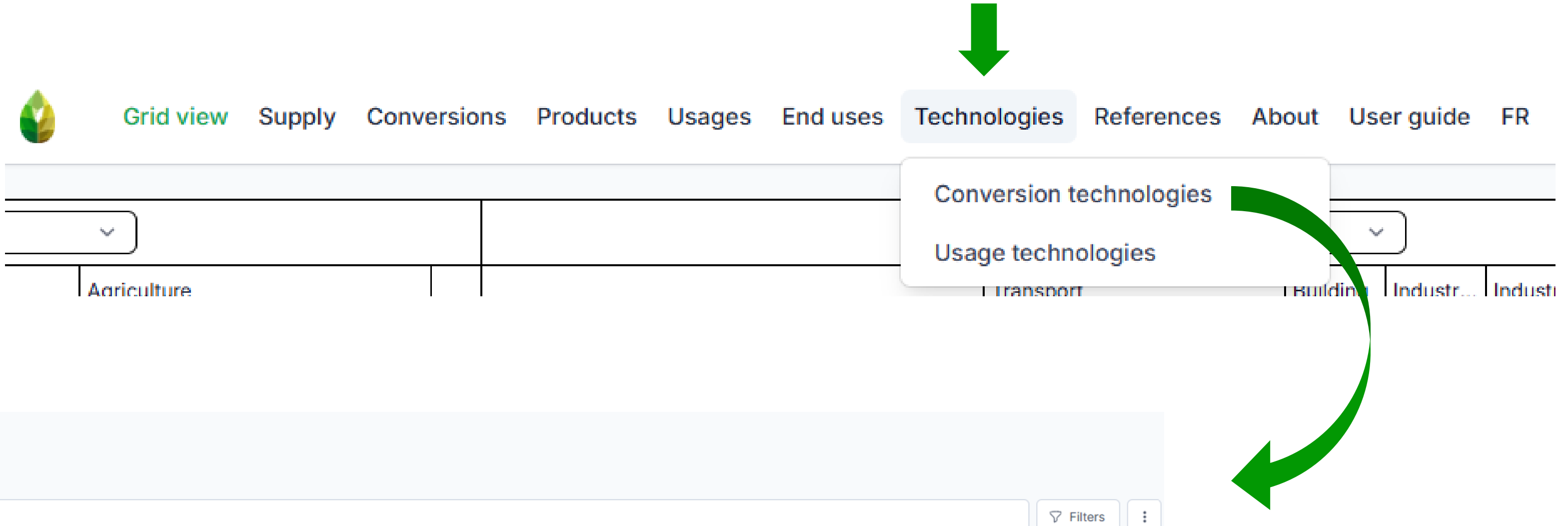


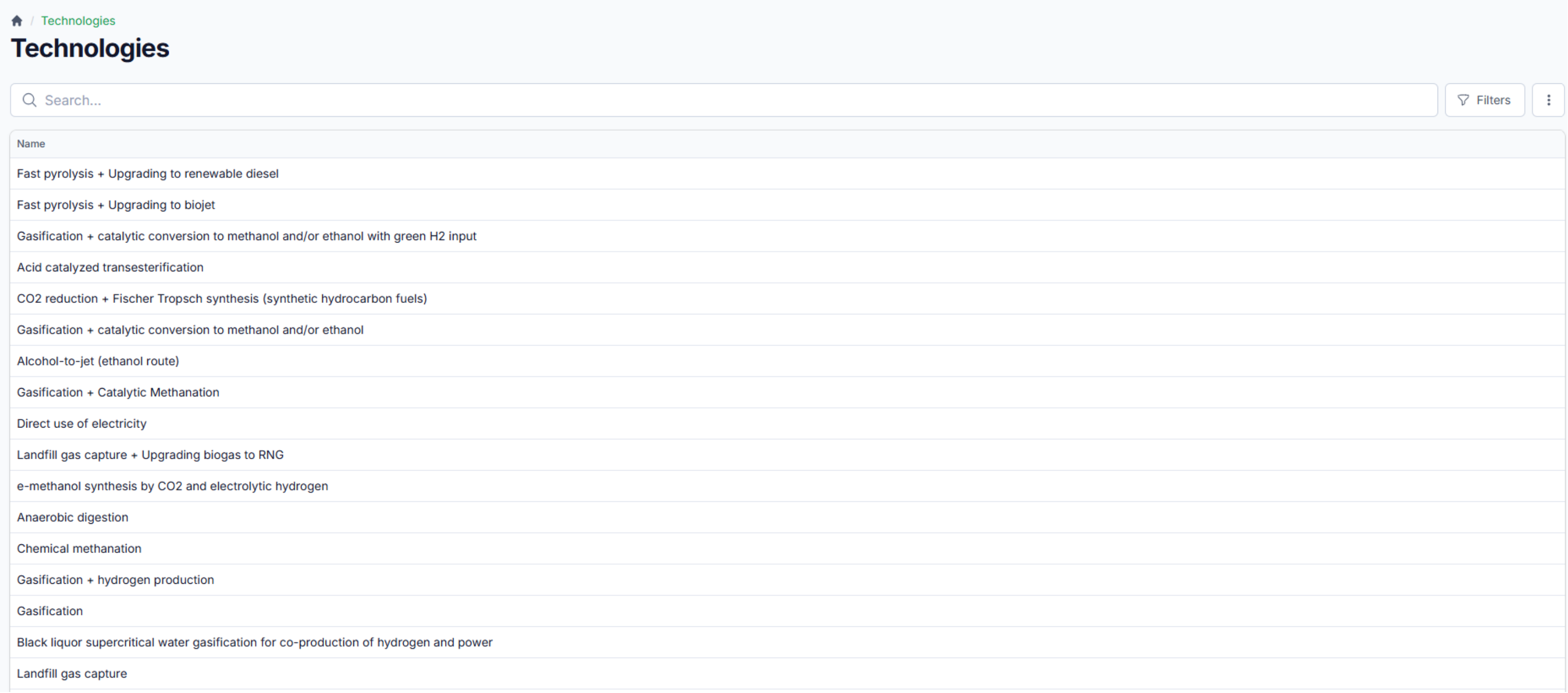
Usage technologies

(e.g., boilers, internal combustion engine, heat pumps)

The Grid view

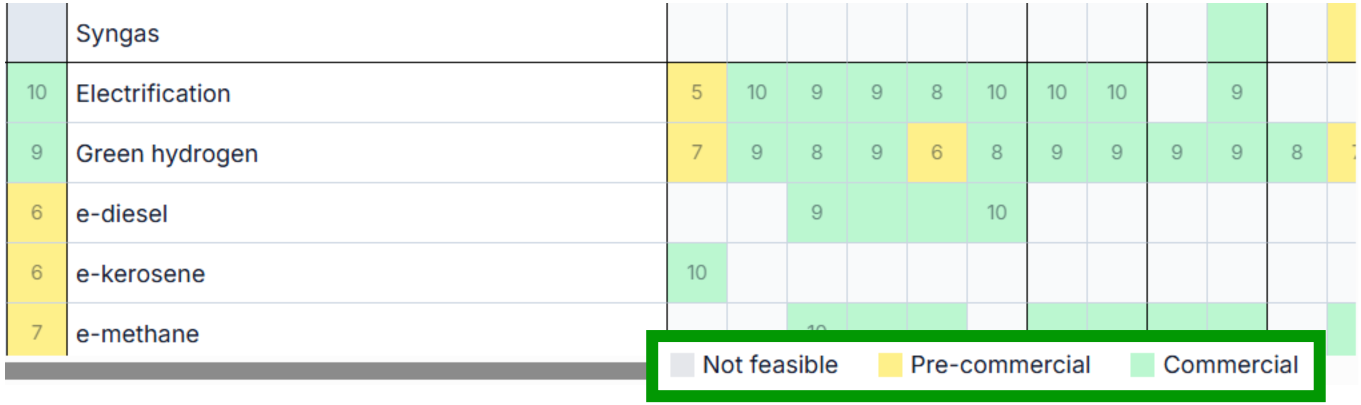
The lists of conversion and usage technologies are accessible from the navigation bar.





The Grid view

The color code on the Grid view is an indication of the commercial readiness of the technologies corresponding to a certain conversion or usage.



The legend is available on the Grid view:

Not feasible = no technology was found that can be used to transform the considered feedstock to the considered bioproduct.

Pre-commercial = The most recent TRL found is below 8 and/or no commercial facility exists to our knowledge.

Commercial = The most recent TRL found is above 8 and/or a commercial facility exists either in Canada or abroad.

The Grid view

For a certain **conversion** (Supply to Product), it is possible to have multiple **technologies**.

- The figure shows an example for a **conversion** of wood transformation residues (supply) to Renewable Natural Gas (Product).
- There are 2 types of **technologies** that are being developed and that potentially could be used for this conversion: pyrocatalytic hydrogenation and gasification followed by catalytic methanation.

Conversion attribute: Energy conversion efficiency %

Urban and rural waste					Forestry							Agriculture								
Landfill gas (methane portion)	Tallow	Urban organic waste	Wood and wood products	Yellow Grease	Black liquor	Harvested wood	Logging residues	Salvaged wood	Unharvested wood within the w...	Wood from thinnings	Wood transformation residues	Animal manure	Canola crops	Corn crops	Corn stover	Soybean crops	Straw	Wheat crops	Electricity	
		82	82			82	82	82	82	82	82	82			82		82			Bio-crude (HTL)
			61			50	50	50	50	50	61				50		50			Bio-hydrogen
																				Biocarbon
			39			39	39	39	39	39	39	38			40		40			Biochar
			90			90	90	90	90	90	90				90		90			Biocoal (torrefied wood pellets)
	86			86									90			90				Biodiesel (FAME)
			41			35	35	35	35	35	41			46	41		41	46		Bioethanol (fermentation)
			46			46	46	46	46	46	46				25		25			Bioethanol (gasification)
		60										60			60		60			Biogas
			60			12	12	12	12	12	60				60		60			Biojet (FT)
	67			67									67			67				Biojet (HEFA)
																				Biojet (UHTL)
																				Biojet (UPO)
			10			10	10	10	10	10	10			10	10		10	10		Biojet (ethanol ATJ)
																				Biojet (isobutanol ATJ)
			70		60	70	70	70	70	70	70				70		70			Biomethanol (gasification)
																				Food or Feed
																				Lumber
			100		100	100	100	100	100	100	100	100			100		100			No conversion
																				Pulp and paper
			68			68	68	68	68	68	68				60		60			Pyrolysis oil (PO)
		53	70			63	70	63	63	63	70	53			53		53			Renewable Natural Gas
			15			10	10	10	10	10	1									ble diesel (FT)
	85			85																ble diesel (HDRD/HVO)
																				ble diesel (UHTL)
																				ble diesel (UPO)

Conversion	Energy conversion efficiency
Pyrocatalytic hydrogenation	70%
Gasification + Catalytic Methanation	63%

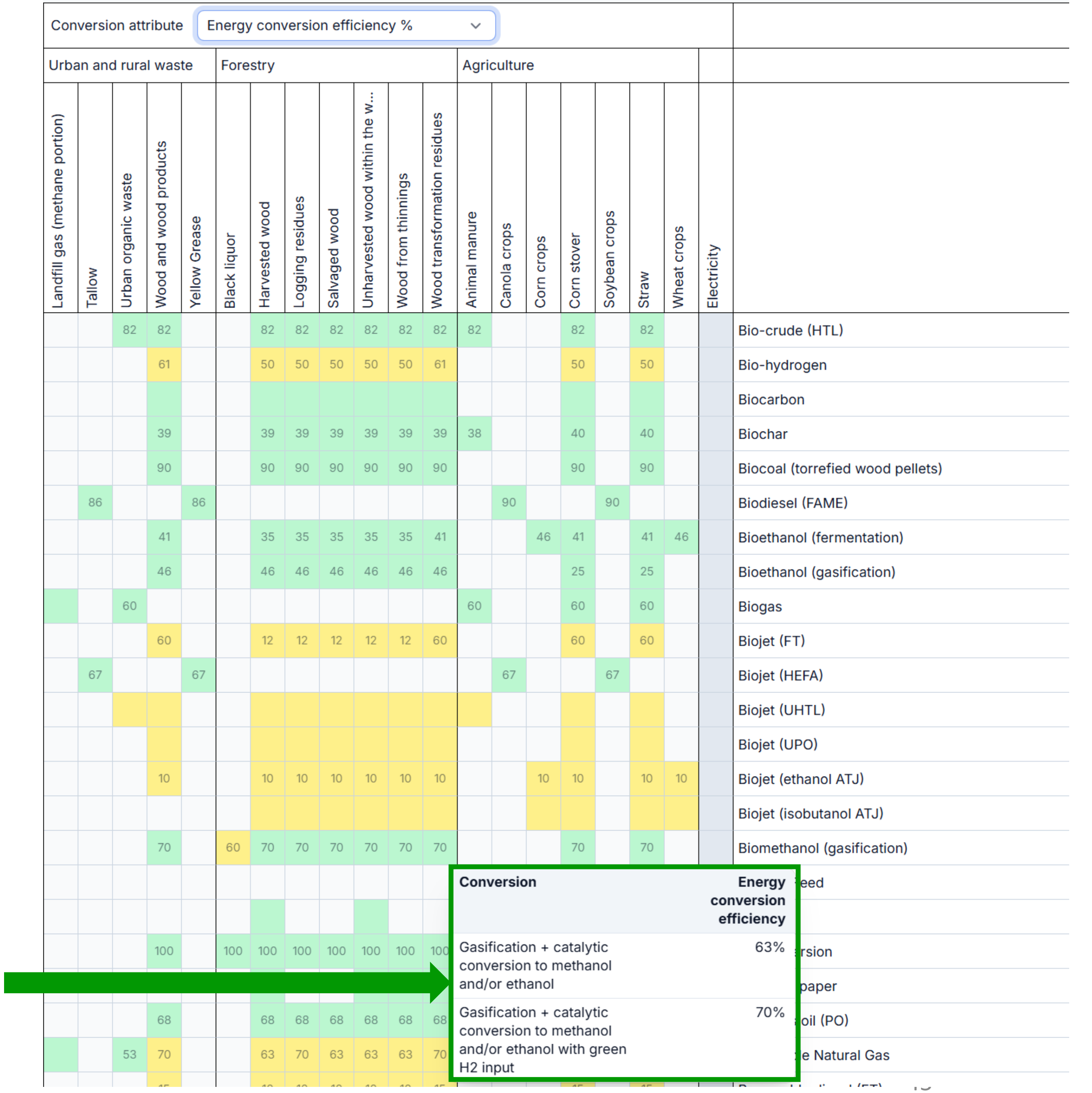
Technologies

The Grid view

The figure on this slide shows another example.

- **Conversion** of wood transformation residues (supply) to biomethanol (Product).
- There are 2 types of **technologies** in the database that potentially could be used for this conversion.
- In this case, the two technologies are similar, however, in the second case there is integration of external H_2 input in the process which results in different efficiency values.

Technologies



Conversion attribute: Energy conversion efficiency %

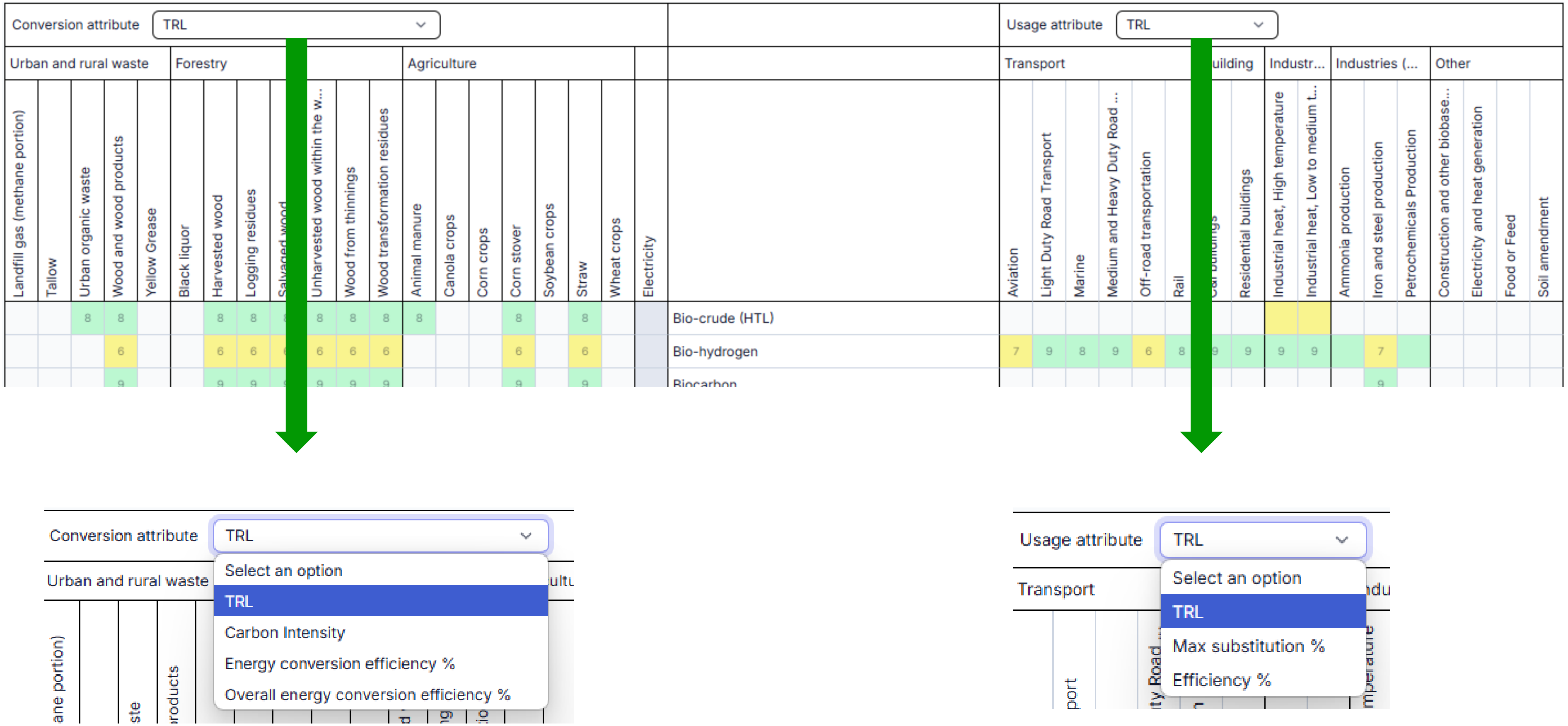
Urban and rural waste					Forestry							Agriculture								
Landfill gas (methane portion)	Tallow	Urban organic waste	Wood and wood products	Yellow Grease	Black liquor	Harvested wood	Logging residues	Salvaged wood	Unharvested wood within the w...	Wood from thinnings	Wood transformation residues	Animal manure	Canola crops	Corn crops	Corn stover	Soybean crops	Straw	Wheat crops	Electricity	
		82	82			82	82	82	82	82	82	82			82		82			Bio-crude (HTL)
			61			50	50	50	50	50	61				50		50			Bio-hydrogen
																				Biocarbon
			39			39	39	39	39	39	39	38			40		40			Biochar
			90			90	90	90	90	90	90				90		90			Biocoal (torrefied wood pellets)
	86			86									90			90				Biodiesel (FAME)
			41			35	35	35	35	35	41			46	41		41	46		Bioethanol (fermentation)
			46			46	46	46	46	46	46				25		25			Bioethanol (gasification)
		60										60			60		60			Biogas
			60			12	12	12	12	12	60				60		60			Biojet (FT)
	67			67									67			67				Biojet (HEFA)
																				Biojet (UHTL)
																				Biojet (UPO)
			10			10	10	10	10	10	10			10	10		10	10		Biojet (ethanol ATJ)
																				Biojet (isobutanol ATJ)
			70		60	70	70	70	70	70	70				70		70			Biomethanol (gasification)
																				eed
			100		100	100	100	100	100	100	100									rsion
																				paper
			68			68	68	68	68	68	68									oil (PO)
		53	70			63	70	63	63	63	70									e Natural Gas

Conversion	Energy conversion efficiency
Gasification + catalytic conversion to methanol and/or ethanol	63%
Gasification + catalytic conversion to methanol and/or ethanol with green H2 input	70%

The Grid view

The indicator shown by default on the grid view is the technology readiness level (TRL).

The two bars above the "conversion" and "usage" sides of the Grid view, can be used to select the indicator that appears on the Grid.

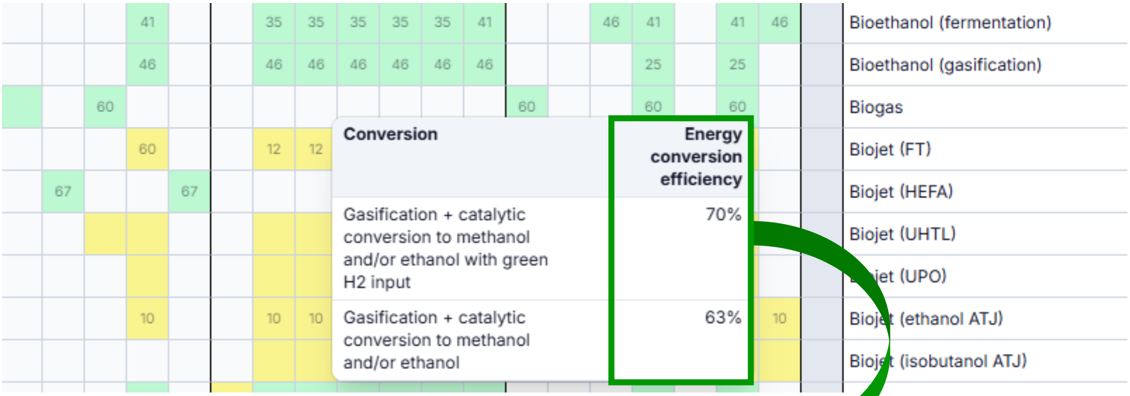


The Grid view

- After selecting a certain indicator, all values presented on the grid view will show the values corresponding to the chosen indicator.
- This figure shows an example for the selection of “Energy conversion efficiency” as an indicator.
- By looking at the conversion example of wood transformation residues (supply) to biomethanol (Product): the value shown on the grid view is 70%.
- This value corresponds **to the most optimist value that exist in the database for this conversion (among all potential technologies)**.
- By passing the mouse curser on the cell of “70%”, a box opens which shows the most optimist value for each potential technology that can be used for this conversion.

The Grid view

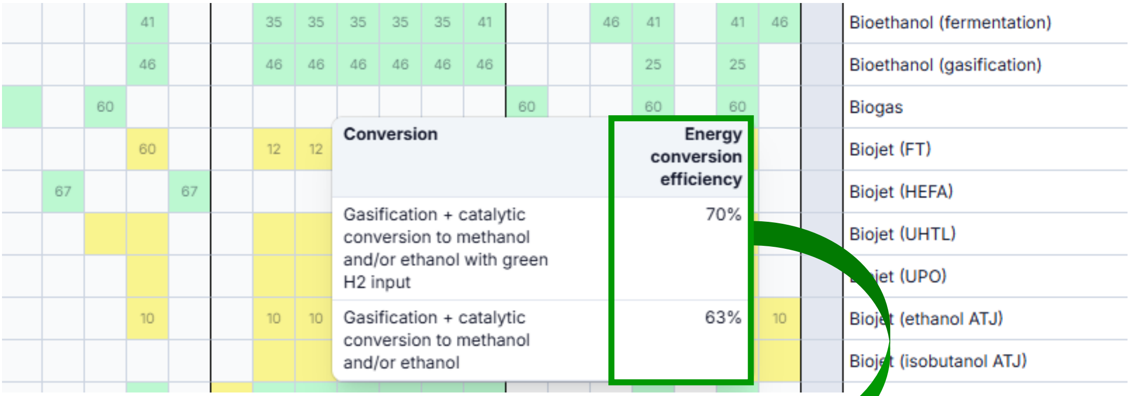
- By clicking on the “70%” cell, the corresponding page opens that presents the list of conversion options (technologies).



Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + catalytic conversion to methanol and/or ethanol	Commercial	9	63	89
Gasification + catalytic conversion to methanol and/or ethanol with green H2 input	Commercial	9	70	82

The Grid view



- By clicking on the "70%" cell, the corresponding page opens that presents the list of conversion options (technologies).

Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + catalytic conversion to methanol and/or ethanol	Commercial	9	63	89
Gasification + catalytic conversion to methanol and/or ethanol with green H2 input	Commercial	9	70	82

- By selecting a certain technology, a page opens that contains all data available in the database with their references, and detailed energy balance.

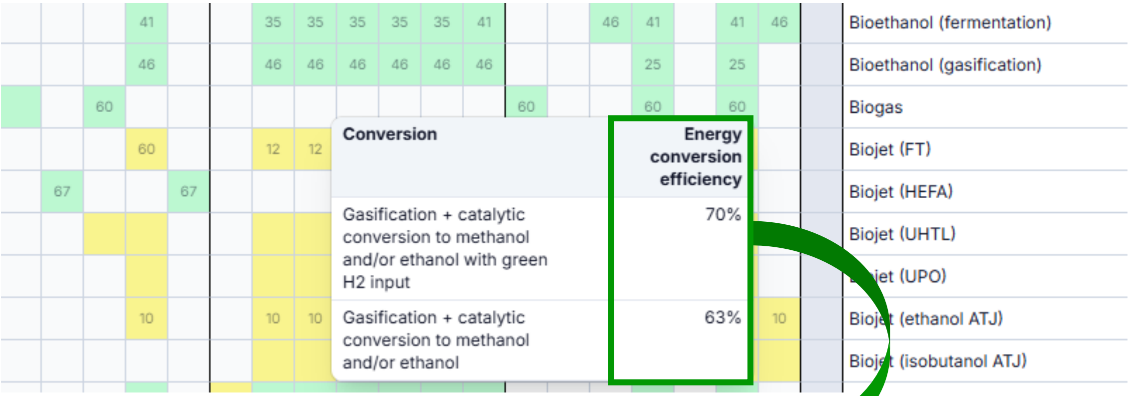
Conversion values

Conversion efficiency (%)	Overall efficiency (%)	Main input	Other inputs	Main output	Other outputs	Note	References
70	82	59.5	40.5 Power (for H2)	69.6	10.6 District heat 1.6 Electricity	-	Danish Energy Agency 2024

- Note that for the same conversion option, we can have multiple **conversion values** in the database from **different references.**

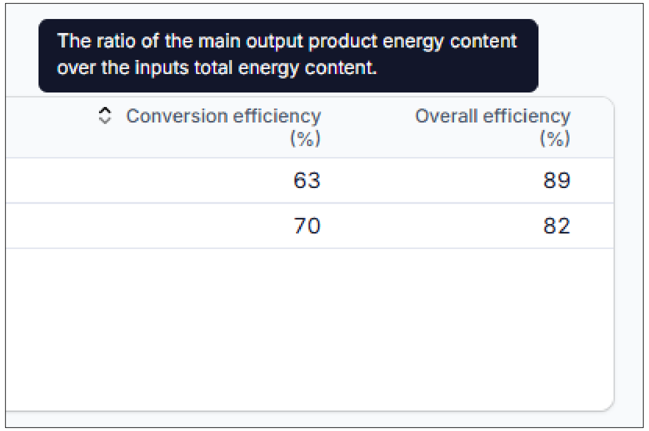
The Grid view

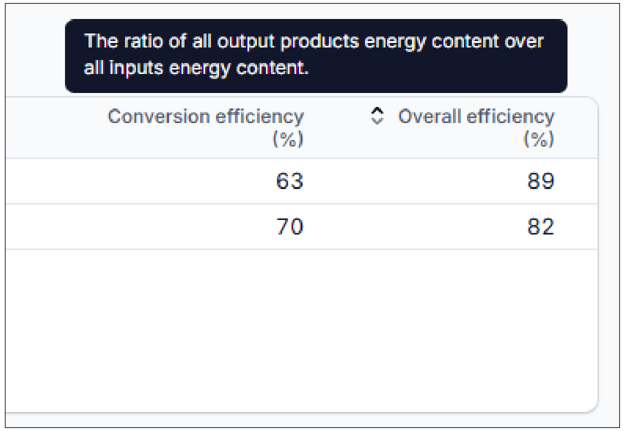
Note : the definition of each indicator appear by passing the mouse cursor over the name of the indicator.



Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + catalytic conversion to methanol and/or ethanol	Commercial	9	63	89
Gasification + catalytic conversion to methanol and/or ethanol with green H2 input	Commercial	9	70	82





The Grid view

Example of a conversion option that has multiple conversion values in the database

- **Conversion**: Wood transformation residues to Renewable diesel (FT)
- **Conversion option**: By using Gasification + Fischer Tropsch (*1 option possible*)
- **Conversion values**: overall efficiency varies from 25 to 64 depending on the reference (*4 references are added for this conversion option*)

Conversions / Wood transformation residue... / Gasification + Fischer Tropsch

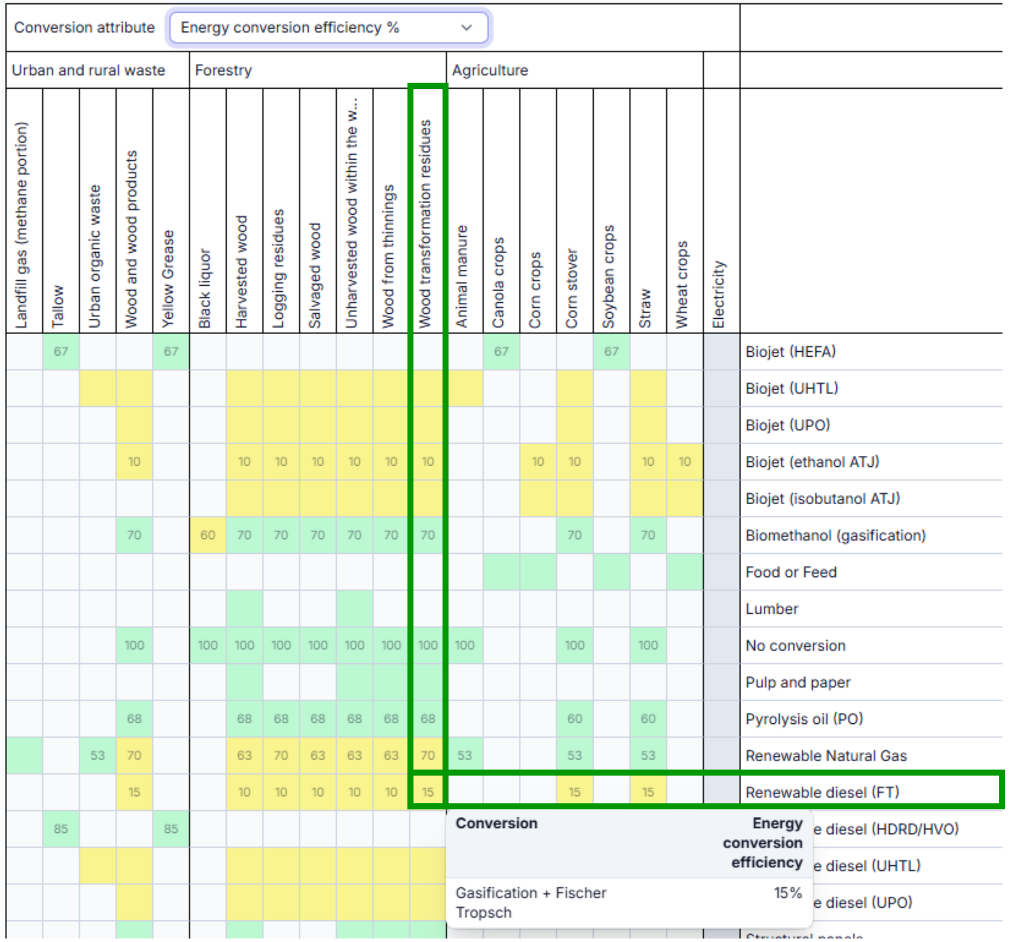
Wood transformation residues → Renewable diesel (FT) / Gasification + Fischer Tropsch

Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + Fischer Tropsch	Pre-commercial	7	15	64

Conversion values

Conversion efficiency (%)	Overall efficiency (%)	Main input	Other inputs	Main output	Other outputs	Note	References
15	25	-	-	-	-	Not specified if energy based	IEA Bioenergy 2024a
10	40	100	-	9.98	1.2 Electrification 13.8 Naphtha 14.7 Biojet (FT)	-	Danish Energy Agency 2024
-	53	-	-	-	-	High temperature scenario	Swanson et al. 2010
-	64	-	-	-	-	Not specified in the reference which inputs and...	Vaillancourt, Bahn, and Levasseur 2019



Conversion attribute: Energy conversion efficiency %

	Urban and rural waste					Forestry							Agriculture							
	Landfill gas (methane portion)	Tallow	Urban organic waste	Wood and wood products	Yellow Grease	Black liquor	Harvested wood	Logging residues	Salvaged wood	Unharvested wood within the w...	Wood from thinnings	Wood transformation residues	Animal manure	Canola crops	Corn crops	Corn stover	Soybean crops	Straw	Wheat crops	Electricity
Biojet (HEFA)		67			67									67			67			
Biojet (UHTL)																				
Biojet (UPO)																				
Biojet (ethanol ATJ)				10			10	10	10	10	10	10			10	10		10	10	
Biojet (isobutanol ATJ)																				
Biomethanol (gasification)				70		60	70	70	70	70	70	70				70		70		
Food or Feed																				
Lumber																				
No conversion				100		100	100	100	100	100	100	100	100			100		100		
Pulp and paper																				
Pyrolysis oil (PO)				68			68	68	68	68	68	68				60		60		
Renewable Natural Gas			53	70			63	70	63	63	63	70	53			53		53		
Renewable diesel (FT)				15			10	10	10	10	10	15				15		15		
...e diesel (HDRD/HVO)		85			85															
...e diesel (UHTL)																				
...e diesel (UPO)																				

Conversion	Energy conversion efficiency
Gasification + Fischer Tropsch	15%

The Grid view

Conversion examples

- ‘Conversion examples’ consists of examples of existing or announced facilities either in Canada or abroad that use or are planned to use the selected conversion technology
- Depending on data availability, each conversion example include the announced yearly production capacity of the facility and the corresponding year

Wood transformation residues → Biomethanol (gasification) / Gasification + catalytic conversion to methanol and/or ethanol wit…

Main input
Wood transformation residues

Main output
Biomethanol (gasification)

Technology
Gasification + catalytic conversion to methanol and/or ethanol with green H2 input

Carbon Intensity
10 g CO2e/MJ

TRL
9
(Commercial)
IEA Bioenergy, n.d.a

Code
GASMESH2.WTR.BMETH

Conversion values

Conversion efficiency (%)	Overall efficiency (%)	Main input	Other inputs	Main output	Other outputs	Note	References
70	82	59.5	40.5 Power (for H2)	69.6	10.6 District heat 1.6 Electricity	-	Danish Energy Agency 2024

Conversion examples

Facility name	Year	Yearly production capacity	References	Note
Varennes Carbon Recycling, Partnership including Enerkem, QC, Canada	2026	125 million litres biofuels	Enerkem, n.d.	The year corresponds to the scheduled date.

The Grid view

Carbon intensity (CI)

- For each conversion, CI values are presented in the tool under the ‘Carbon intensity values’ table
- CI values are also accessible through the grid view
- The most optimist value (the lowest) is presented on the Grid view
- All CI values available in the database are presented on the page that is specific to the chosen conversion

Conversions / Wood transformation residue...

Wood transformation residues → Renewable diesel (FT)

Main input	Wood transformation residues
Main output	Renewable diesel (FT)
Code	WTR.FTRD

Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + Fischer Tropsch	Pre-commercial	7	15	64

Carbon intensity values

Region	Year	Methodology	Carbon Intensity (g CO2e/MJ)	Note	References
Alberta	2024	Unknown	-44	Expected CI for the Bio-SynDiesel in ideal cond...	Church 2024
Alberta	2024	Unknown	32.5	Estimated CI for the Bio-SynDiesel project in C...	Expander Technologies Inc 2024

The Grid view

- Average CI values in Canada are presented when data is available
- If average value is not found, CI values for specific projects are added
- If no project is found in Canada, but the technology is being developed abroad then the CI value of the developed project is added

Examples

Carbon intensity values

Region	Year	Methodology	Carbon Intensity (g CO2e/MJ)	Note	References
Canada	2021	Fuel LCA model	-6.4	Average value for fuels produced or distributed...	MELCCFP 2022

Carbon intensity values

Region	Year	Methodology	Carbon Intensity (g CO2e/MJ)	Note	References
Alberta	2024	Unknown	-44	Expected CI for the Bio-SynDiesel in ideal cond...	Church 2024
Alberta	2024	Unknown	32.5	Estimated CI for the Bio-SynDiesel project in C...	Expander Technologies Inc 2024

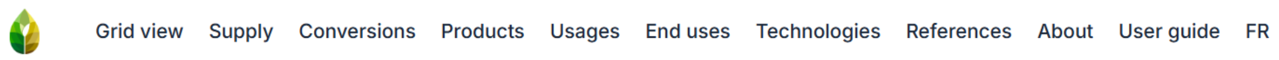
Carbon intensity values

Region	Year	Methodology	Carbon Intensity (g CO2e/MJ)	Note	References
Global	2024	CORSIA	13.9	CORSIA Default Life Cycle Emissions Values that...	ICAO 2024

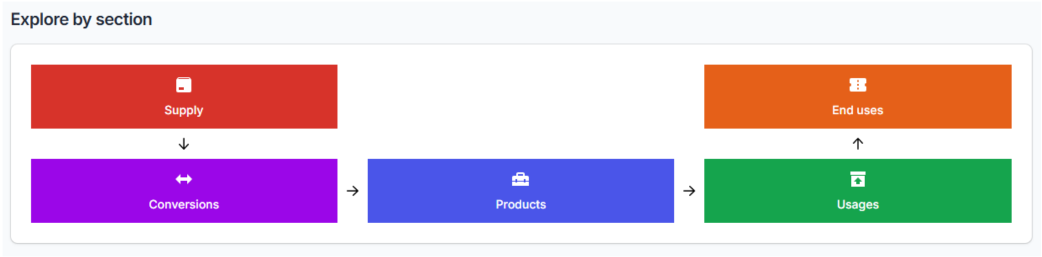
Explore by section

There are 5 main sections in this tool : Supply, conversions, products, usages and end-uses.

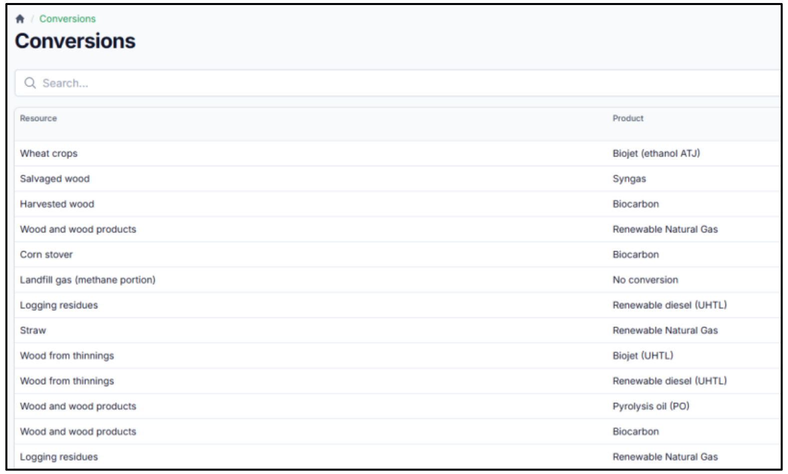
- The main sections can be accessed either from the navigation bar

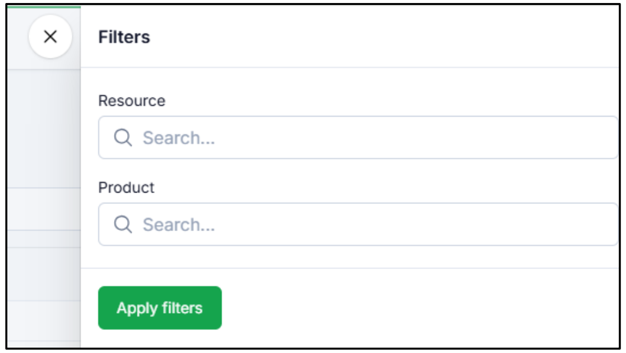


- Or they can be accessed from the home page



- Both access options will lead to the main page of the selected section (example shown below for the ‘conversions’ main page).





Explore by section

Indicators by supply type

Supply

- **Description**

Definitions vary widely in the literature

- **Availability**

Region, Mass/volume, Energy content

- **Conversion options**

Potential products, technologies, TRL, conversion efficiency, overall energy efficiency

- **Potential impact of biomass harvest**

Region, impact, state of scientific evidence

- **Carbon parity time**

For a combination of biomass conversion efficiency, substituted product and reference scenario

Explore by section

The following pages show the example of indicators presented for ‘Logging residues’

/ Supply

Supply

Search... Filters

Name	Supply sector
Corn crops	Agriculture
Urban organic waste	Urban and rural waste
Electricity	Electricity
Wheat crops	Agriculture
Wood transformation residues	Forestry
Black liquor	Forestry
Wood and wood products	Urban and rural waste
Landfill gas (methane portion)	Urban and rural waste
Logging residues	Forestry
Animal manure	Agriculture
Wood from thinnings	Forestry
Corn stover	Agriculture
Canola crops	Agriculture
Unharvested wood within the wood supply limit	Forestry
Soybean crops	Agriculture
Salvaged wood	Forestry

Explore by section

Description of ‘Logging residues’

Supply / Logging residues

Logging residues

Sector

Forestry

Description

Logging residues consist of all branches and foliage not hauled to mills for use in manufacturing standard forest products. Depending on the reference, logging residues could include low-quality logs and tree tops.

The amount of logging residues that could be harvested to be used as feedstocks for bioenergy or biomaterials depends on ecological, technical and economical factors. Residue recovery rates vary with equipment, operator skill, season and stand conditions. A synthesis of operational recovery rates of harvest residues from field trials (scientific studies and technical reports) in boreal and temperate forests indicated that the average recovery rate was 52.2% depending on the country. In Canada, residue removal levels are expected to change over time.

Code

LR

Availability

Region	Year	Energy content	Volume	Mass	Notes	References
Canada	2018	392 PJ	-	21 Mt	In the reference, logging residues are defined ...	Barrette et al. 2018 Thiffault et al. 2016

Conversion options

Main product	Technology	Deployment	TRL	Carbon Intensity (g CO2e/MJ)	Conversion efficiency (%)	Overall efficiency (%)
Biojet (isobutanol ATJ)	Alcohol-to-jet (isobutanol route)	Pre-commercial	7	-	-	-
Renewable diesel (UHTL)	Hydrothermal liquefaction + Upgrading to renewable diesel and biojet	Pre-commercial	4	-	-	-
Bio-crude (HTL)	Hydrothermal liquefaction	Commercial	8	-	82	82
Bioethanol (gasification)	Gasification + catalytic conversion to methanol and/or ethanol	Commercial	8	-	46	60
Biocoal (torrefied wood pellets)	Slow pyrolysis	Commercial	9	14.54	90	90
Biocarbon	Slow pyrolysis	Commercial	9	-	-	-
Bio-hydrogen	Gasification + hydrogen production	Pre-commercial	6	-150	50	56
Biojet (UHTL)	Hydrothermal liquefaction + Upgrading to renewable diesel and biojet	Pre-commercial	4	-	-	-
Bioethanol (fermentation)	Enzymatic hydrolysis + fermentation (cellulosic ethanol)	Commercial	8	-	35	39
Biojet (UPO)	Fast pyrolysis + Upgrading to biojet	Pre-commercial	-	25.7	-	-
No conversion	Direct use of biomass (no conversion)	Commercial	-	-	100	100

Explore by section

Availability: presented by Mass or Volume along with the energy content (before conversion)

Supply / Logging residues

Logging residues

Sector

Forestry

Description

Logging residues consist of all branches and foliage not hauled to mills for use in manufacturing standard forest products. Depending on the reference, logging residues could include low-quality logs and tree tops.

The amount of logging residues that could be harvested to be used as feedstocks for bioenergy or biomaterials depends on ecological, technical and economical factors. Residue recovery rates vary with equipment, operator skill, season and stand conditions. A synthesis of operational recovery rates of harvest residues from field trials (scientific studies and technical reports) in boreal and temperate forests indicated that the average recovery rate was 52.2% depending on the country. In Canada, residue removal levels are expected to change over time.

Code

LR

Availability

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Conversion options

Main product	Technology	Deployment	TRL	Carbon Intensity (g CO2e/MJ)	Conversion efficiency (%)	Overall efficiency (%)
Biojet (isobutanol ATJ)	Alcohol-to-jet (isobutanol route)	Pre-commercial	7	-	-	-
Renewable diesel (UHTL)	Hydrothermal liquefaction + Upgrading to renewable diesel and biojet	Pre-commercial	4	-	-	-
Bio-crude (HTL)	Hydrothermal liquefaction	Commercial	8	-	82	82
Bioethanol (gasification)	Gasification + catalytic conversion to methanol and/or ethanol	Commercial	8	-	46	60
Biocoal (torrefied wood pellets)	Slow pyrolysis	Commercial	9	14.54	90	90
Biocarbon	Slow pyrolysis	Commercial	9	-	-	-
Bio-hydrogen	Gasification + hydrogen production	Pre-commercial	6	-150	50	56
Biojet (UHTL)	Hydrothermal liquefaction + Upgrading to renewable diesel and biojet	Pre-commercial	4	-	-	-
Bioethanol (fermentation)	Enzymatic hydrolysis + fermentation (cellulosic ethanol)	Commercial	8	-	35	39
Biojet (UPO)	Fast pyrolysis + Upgrading to biojet	Pre-commercial	-	25.7	-	-
No conversion	Direct use of biomass (no conversion)	Commercial	-	-	100	100

Explore by section

Conversion options

Conversion options show potential products that can be produced and technologies that can be used for a certain supply type.

Conversion options

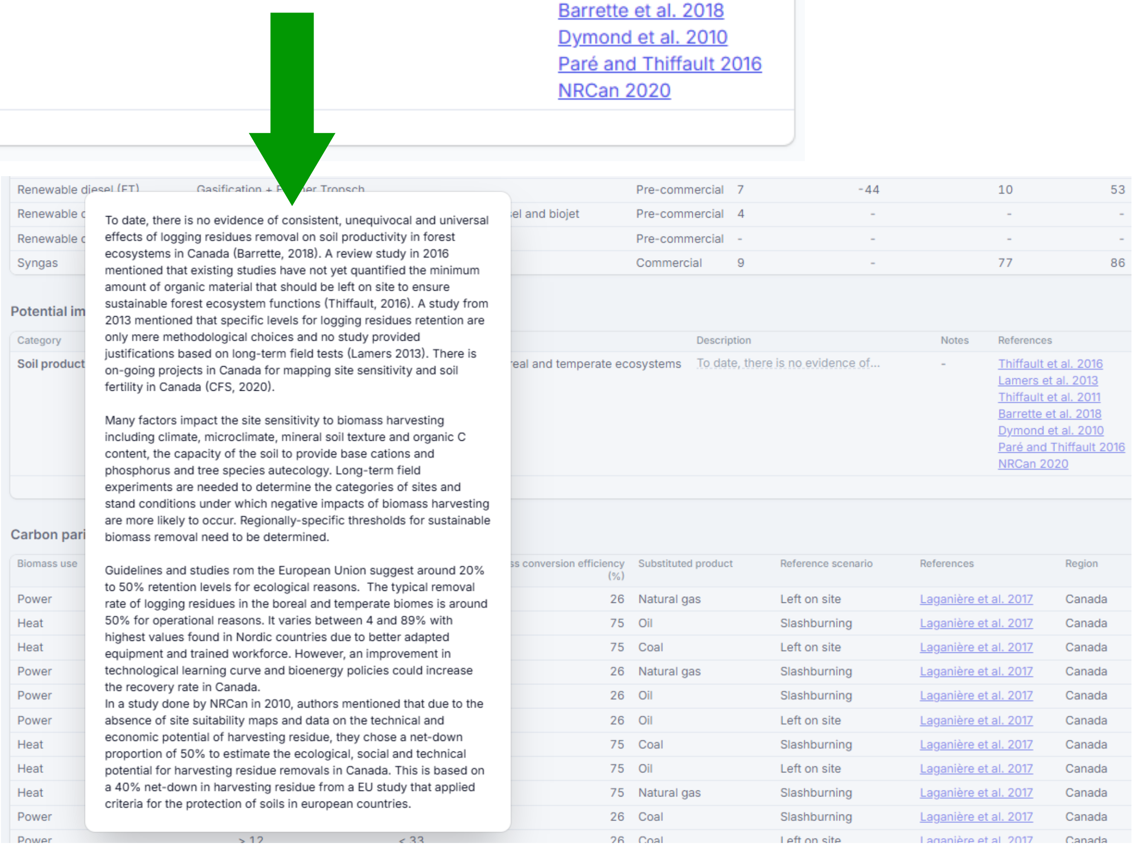
Main product	Technology	Deployment	TRL	Carbon Intensity (g CO2e/MJ)	Conversion efficiency (%)	Overall efficiency (%)
Bio-crude (HTL)	Hydrothermal liquefaction	Commercial	8	-	82	82
Bio-hydrogen	Gasification + hydrogen production	Pre-commercial	6	-150	50	56
Biocarbon	Slow pyrolysis	Commercial	9	-	-	-
Biochar	Slow pyrolysis	Commercial	9	-	39	80
Biocoal (torrefied wood pellets)	Slow pyrolysis	Commercial	9	14.54	90	90
Bioethanol (fermentation)	Enzymatic hydrolysis + fermentation (cellulosic ethanol)	Commercial	8	-	35	39
Bioethanol (gasification)	Gasification + catalytic conversion to methanol and/or ethanol	Commercial	8	-	46	60
Biojet (FT)	Gasification + Fischer Tropsch (optimized for jet)	Pre-commercial	7	-375	12	20
Biojet (UHTL)	Hydrothermal liquefaction + Upgrading to renewable diesel and biojet	Pre-commercial	4	-	-	-
Biojet (UPO)	Fast pyrolysis + Upgrading to biojet	Pre-commercial	-	25.7	-	-
Biojet (ethanol ATJ)	Alcohol-to-jet (ethanol route)	Pre-commercial	7	-	10	13
Biojet (isobutanol ATJ)	Alcohol-to-jet (isobutanol route)	Pre-commercial	7	-	-	-
Biomethanol (gasification)	Gasification + catalytic conversion to methanol and/or ethanol with green H2 input	Commercial	9	-	70	82
Biomethanol (gasification)	Gasification + catalytic conversion to methanol and/or ethanol	Commercial	9	-	63	89
No conversion	Direct use of biomass (no conversion)	Commercial	-	-	100	100
Pyrolysis oil (PO)	Fast pyrolysis	Commercial	9	-	68	85
Renewable Natural Gas	Gasification + Catalytic Methanation	Pre-commercial	7	-	63	85
Renewable Natural Gas	Pyrocatalytic hydrogenation	Pre-commercial	-	-	70	-
Renewable diesel (FT)	Gasification + Fischer Tropsch	Pre-commercial	7	-44	10	53
Renewable diesel (UHTL)	Hydrothermal liquefaction + Upgrading to renewable diesel and biojet	Pre-commercial	4	-	-	-
Renewable diesel (UPO)	Fast pyrolysis + Upgrading to renewable diesel	Pre-commercial	-	-	-	-
Syngas	Gasification	Commercial	9	-	77	86

Explore by section

Potential impact of biomass harvest: A brief synthesis of the potential impact of biomass harvest for a certain supply type, as concluded from available references.

Potential impact of biomass harvests

Category	Region	Impact	State of scientific evidence	Description	Notes	References
Soil productivity	Canada	Site-specific	No sufficient long-term field evidence for boreal and temperate ecosystems in Canada	To date, there is no evidence of...	-	Thiffault et al. 2016 Lamers et al. 2013 Thiffault et al. 2011 Barrette et al. 2018 Dymond et al. 2010 Paré and Thiffault 2016 NRCan 2020



Explore by section

Carbon parity time

Carbon parity time values published in scientific articles and public reports can be added for a combination of supply type, biomass conversion efficiency and substituted product.

Information on the corresponding biomass use case and region considered in the analysis needs to be added as well.

Carbon parity times

Biomass use	Min carbon parity time (in years)	Max carbon parity time (in years)	Biomass conversion efficiency (%)	Substituted product	Reference scenario	References	Region
Power	> 100	> 100	26	Natural gas	Left on site	Laganière et al. 2017	Canada
Heat	0	0	75	Oil	Slashburning	Laganière et al. 2017	Canada
Heat	> 5	< 14	75	Coal	Left on site	Laganière et al. 2017	Canada
Power	0	0	26	Natural gas	Slashburning	Laganière et al. 2017	Canada
Power	0	0	26	Oil	Slashburning	Laganière et al. 2017	Canada
Power	> 21	< 68	26	Oil	Left on site	Laganière et al. 2017	Canada
Heat	0	0	75	Coal	Slashburning	Laganière et al. 2017	Canada
Heat	> 8	< 23	75	Oil	Left on site	Laganière et al. 2017	Canada
Heat	0	0	75	Natural gas	Slashburning	Laganière et al. 2017	Canada
Power	0	0	26	Coal	Slashburning	Laganière et al. 2017	Canada
Power	> 12	< 33	26	Coal	Left on site	Laganière et al. 2017	Canada
Heat	> 27	< 67	75	Natural gas	Left on site	Laganière et al. 2017	Canada

Explore by section

The following pages show the example of indicators presented for the conversion "Logging residues" to "Renewable diesel (FT)"

Conversions

Conversions

Search... Filters

Resource	Product	Carbon Intensity (g CO2e/MJ)
Wood and wood products	Renewable diesel (UPO)	-
Salvaged wood	Renewable diesel (UPO)	-
Logging residues	Renewable diesel (UPO)	-
Wood from thinnings	Renewable diesel (UPO)	-
Wood transformation residues	Renewable diesel (UPO)	-
Straw	Renewable diesel (UPO)	-
Corn stover	Renewable diesel (UPO)	-
Harvested wood	Renewable diesel (UPO)	-
Unharvested wood within the wood supply limit	Renewable diesel (UPO)	-
Salvaged wood	Biochar	-
Wood and wood products	Bioethanol (fermentation)	-55
Salvaged wood	Biocarbon	-
Corn stover	Renewable diesel (UHTL)	-
Unharvested wood within the wood supply limit	Biocoal (torrefied wood pellets)	-
Logging residues	Biojet (FT)	-375
Wood and wood products	Renewable diesel (FT)	-44
Harvested wood	Renewable Natural Gas	-
Unharvested wood within the wood supply limit	Biojet (isobutanol ATJ)	-
Logging residues	Renewable diesel (FT)	-44
Wood from thinnings	Renewable Natural Gas	-

Explore by section

Conversion options + carbon intensity values for the selected conversion

Conversions / Logging residues → Renewabl...

Logging residues → Renewable diesel (FT)

Main input
Logging residues

Main output
Renewable diesel (FT)

Code
LR.FTRD

Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + Fischer Tropsch	Pre-commercial	7	10	53

Carbon intensity values

Region	Year	Methodology	Carbon Intensity (g CO2e/MJ)	Note	References
Alberta	2024	Unknown	32.5	Estimated CI for the Bio-SynDiesel project in C...	Expander Technologies Inc 2024
Alberta	2024	Unknown	-44	Expected CI for the Bio-SynDiesel in ideal cond...	Church 2024

Explore by section

By clicking on a certain conversion option: a new page opens that presents the corresponding conversion values and conversion examples

Conversions / Logging residues → Renewabl...

Logging residues → Renewable diesel (FT)

Main input
Logging residues

Main output
Renewable diesel (FT)

Code
LR.FTRD

Conversion options

Technology	Deployment	TRL	Conversion efficiency (%)	Overall efficiency (%)
Gasification + Fischer Tropsch	Pre-commercial	7	10	53

Conversion values corresponding to the selected **conversion option**

Conversions / Logging residues → Renewab... / Gasification + Fischer Tropsch

Logging residues → Renewable diesel (FT) / Gasification + Fischer Tropsch

Main input
Logging residues

Main output
Renewable diesel (FT)

Technology
Gasification + Fischer Tropsch

Carbon Intensity
-44 g CO2e/MJ

TRL
7
(Pre-commercial)
IEA 2024

Code
GASFT.LR.FTRD

Conversion values

Conversion efficiency (%)	Overall efficiency (%)	Main input	Other inputs	Main output	Other outputs	Note	References
10	40	100	-	9.98	1.2 Electrification 14.7 Biojet (FT) 13.8 Naphtha	-	Danish Energy Agency 2024
-	53	-	-	-	-	High temperature scenario	Swanson et al. 2010

Conversion examples

Facility name	Year	Yearly production capacity	References	Note
Carseland project in Alberta by Expander Energy and Cielo Waste Solutions	2026	-	Church 2024	The year corresponds to the expected date. As...

Explore by section

Example of indicators presented for the product “Biodiesel (FAME)”

Products / Biodiesel (FAME)

Biodiesel (FAME)

Category	Bioproduct
Description	Fatty acid methyl ester (FAME) produced by transesterification of vegetable oils or animal fats. Biodiesel is not fully compatible with diesel engines and is usually blended with petroleum diesel.
Code	BIODIESEL

References

Citation
Government of Canada 2025c

Conversion options

Main resource	Technology	Deployment	TRL	Carbon Intensity (g CO2e/MJ)	Conversion efficiency (%)	Overall efficiency (%)
Canola crops	Transesterification	Commercial	10	2	90	94
Yellow Grease	Acid catalyzed transesterification	Commercial	10	4.7	86	97
Soybean crops	Transesterification	Commercial	10	6	90	94
Tallow	Acid catalyzed transesterification	Commercial	10	-1.2	86	97

Usage options

Service	Technology	Max substitution (%)	Max substitution note	Efficiency (%)	Efficiency note	Deployment	TRL	References
Marine	Diesel fuel engine for marine ships	30	Sea trials to date have included FAM...	60	This is for conventional marine...	Commercial	9	Hsieh and Felby 2017 (Efficiency)
Rail	Diesel engines for rail	20	Because B20 is compatible with seal...	40	Range of 30-40%.This is for...	Commercial	10	Mikura International 2024 (Efficiency)
Off-road transportation	Diesel engines	20	Off-road applications such as...	38	Values for conventional diesel...	Commercial	-	McCormick and Moriarty 2009 (Substitution) Hjelkrem et al. 2020 (Efficiency) U.S. Department of Energy 2024b (Efficiency)
Medium and Heavy Duty Road Transport	Diesel engines	20	Generally, B20 and lower-level blend...	45	-	Commercial	-	U.S. DOE 2024c (Substitution) Söderena et al. 2021 (Efficiency)

Description, conversion options and usage options for Biodiesel (FAME) product

Explore by section

Example of indicators presented for the end-use "Aviation"

Description of the end-use sector : includes a synthesis of bioproducts and non-biotechnologies that are being developed or already used in this sector

End uses / Aviation

Aviation

Sector	Transport
Description	Bioproducts: HEFA biojet is currently the major commercially produced SAF (biojet) fuel. Biojet produced from the ATJ process is emerging; the first commercial production facility of LanzaJet opened in Soperton, Georgia in January 2024. The third type of biojet that is near commercialization is based on the Fischer-Tropsch process; the world's largest FT biojet production plant (in Louisiana, US) was announced in April 2024. Another possible biomass use is co-processing lipids and FT-liquids with petroleum jet. This option is approved for a maximum 5% of biobased intermediates. Upgraded biocrude (HTL Oil) and bio-oil (pyrolysis oils) co-processing or use for SAF production is still being pursued but is at lower TRLs and is not yet certified. Many technical challenges will need to be resolved for this pathway. Non-bio alternatives: Electro-fuels (or PtL), the non-bio SAF alternative to biojet, are expected to play a role in this sector after 2030. A demonstration project is underway in Canada with SAF+ consortium (using CO2 from industrial flue gas). In Europe, it was announced in May 2024 that the Swiss company, Metafuels, is planning, in conjunction with European Energy, to construct an e-SAF facility that will be able to produce 12,000 litres of eSAF daily. Liquid hydrogen and battery electric aircraft require further development of aircraft design and infrastructure. They are estimated to start playing a role in reducing the sector's emissions on the longer term. Since neither are feasible for long-haul flights, their role may be limited to regional and short-haul flights. Air Canada has purchased 30 electric regional aircraft to be delivered in 2028. For hydrogen technology, Airbus will conduct hydrogen demonstration flights by 2026.
Code	AV

Usage options

Product	Technology	Max substitution (%)	Max substitution note	Efficiency (%)	Efficiency note	Deployment	TRL	References
Bio-hydrogen	Hydrogen fuel cell aircraft propulsion	-	-	50	Peak efficiency of fu...	Pre-commercial	7	Tiwari, Pekris, and Doherty 2024 (Efficiency)
Biojet (FT)	Jet engines (turbine engine)	50	Maximum blend ratio from...	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)
Biojet (HEFA)	Jet engines (turbine engine)	50	Maximum blend ratio from...	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)
Biojet (UHTL)	Jet engines (turbine engine)	-	Not certified yet by ASTM	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)
Biojet (UPO)	Jet engines (turbine engine)	-	Not certified yet by ASTM	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)
Biojet (ethanol ATJ)	Jet engines (turbine engine)	50	Maximum blend ratio from...	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)
Biojet (isobutanol ATJ)	Jet engines (turbine engine)	50	Maximum blend ratio from...	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)
Electrification	Battery electric plane	-	-	77	For the NASA X-57...	Pre-commercial	5	Chin et al. 2020 (Efficiency)
Green hydrogen	Hydrogen fuel cell aircraft propulsion	-	-	50	Peak efficiency of fu...	Pre-commercial	7	Tiwari, Pekris, and Doherty 2024 (Efficiency)
e-kerosene	Jet engines (turbine engine)	-	-	50	-	Commercial	10	Oğur et al. 2025 (Efficiency)

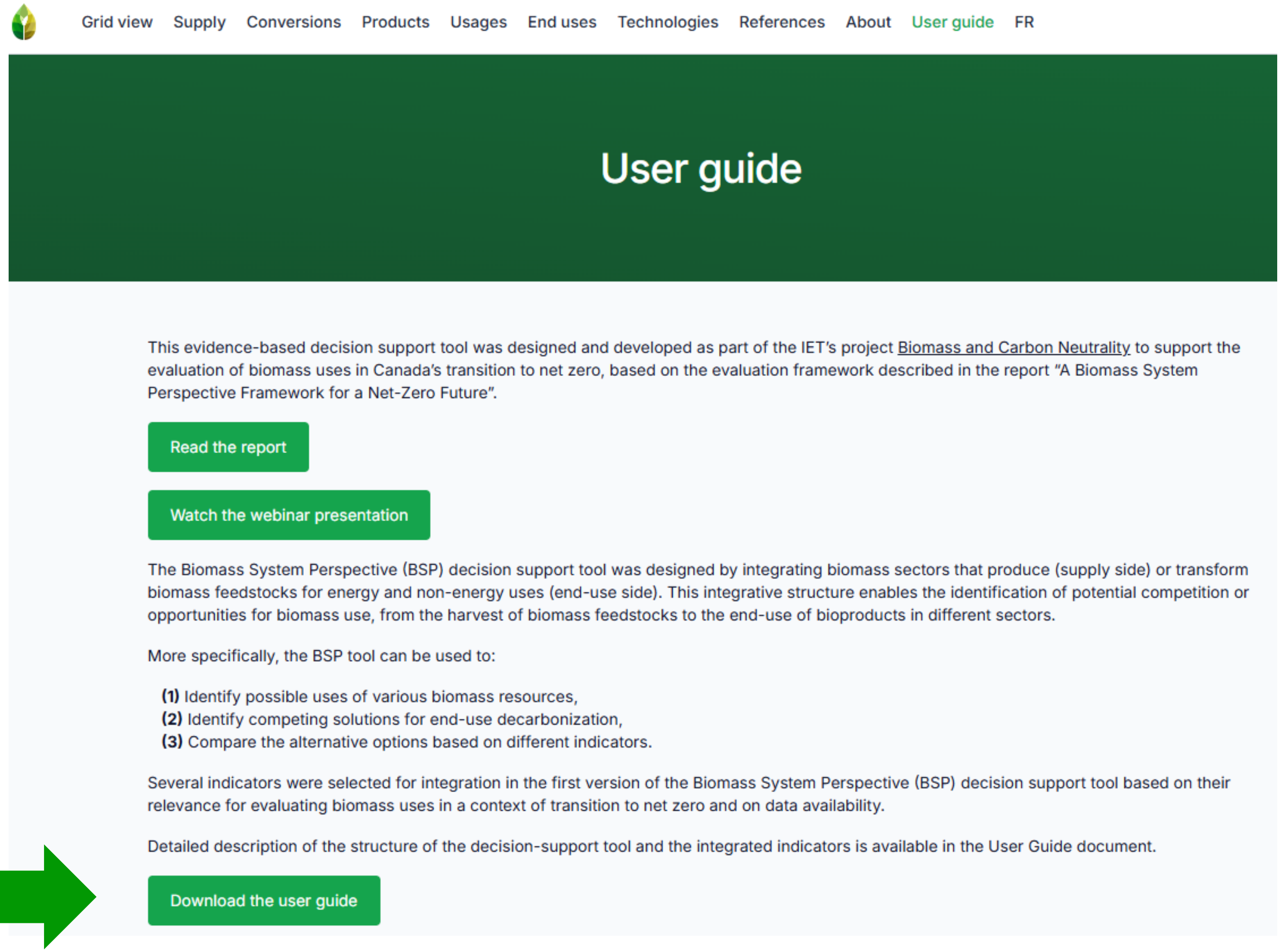
Consumption

Region	Year	Secondary energy	Useful energy conversion factor	Notes	GHG emissions (CO2e)	Notes	References
Canada	2021	154 PJ		-	6 Mt	All types included	Langlois-Bertrand, et al. 2024 (Energy) ECCC 2024a (GHG)

The Biomass System Perspective decision support tool

The User Guide

1. Structure of the BSP tool
    1.1 The Grid View
    1.2 Main sections
    1.3 Indicators
2. Explore the Grid view
    2.1. Overview
    2.2. Navigation
3. Explore by section
    3.1 Supply
    3.2 Conversions
    3.3 Products
    3.4 Usages
    3.5 End-uses


Grid view Supply Conversions Products Usages End uses Technologies References About User guide FR

User guide

This evidence-based decision support tool was designed and developed as part of the IET's project Biomass and Carbon Neutrality to support the evaluation of biomass uses in Canada's transition to net zero, based on the evaluation framework described in the report "A Biomass System Perspective Framework for a Net-Zero Future".

Read the report

Watch the webinar presentation

The Biomass System Perspective (BSP) decision support tool was designed by integrating biomass sectors that produce (supply side) or transform biomass feedstocks for energy and non-energy uses (end-use side). This integrative structure enables the identification of potential competition or opportunities for biomass use, from the harvest of biomass feedstocks to the end-use of bioproducts in different sectors.

More specifically, the BSP tool can be used to:

(1) Identify possible uses of various biomass resources,
(2) Identify competing solutions for end-use decarbonization,
(3) Compare the alternative options based on different indicators.

Several indicators were selected for integration in the first version of the Biomass System Perspective (BSP) decision support tool based on their relevance for evaluating biomass uses in a context of transition to net zero and on data availability.

Detailed description of the structure of the decision-support tool and the integrated indicators is available in the User Guide document.

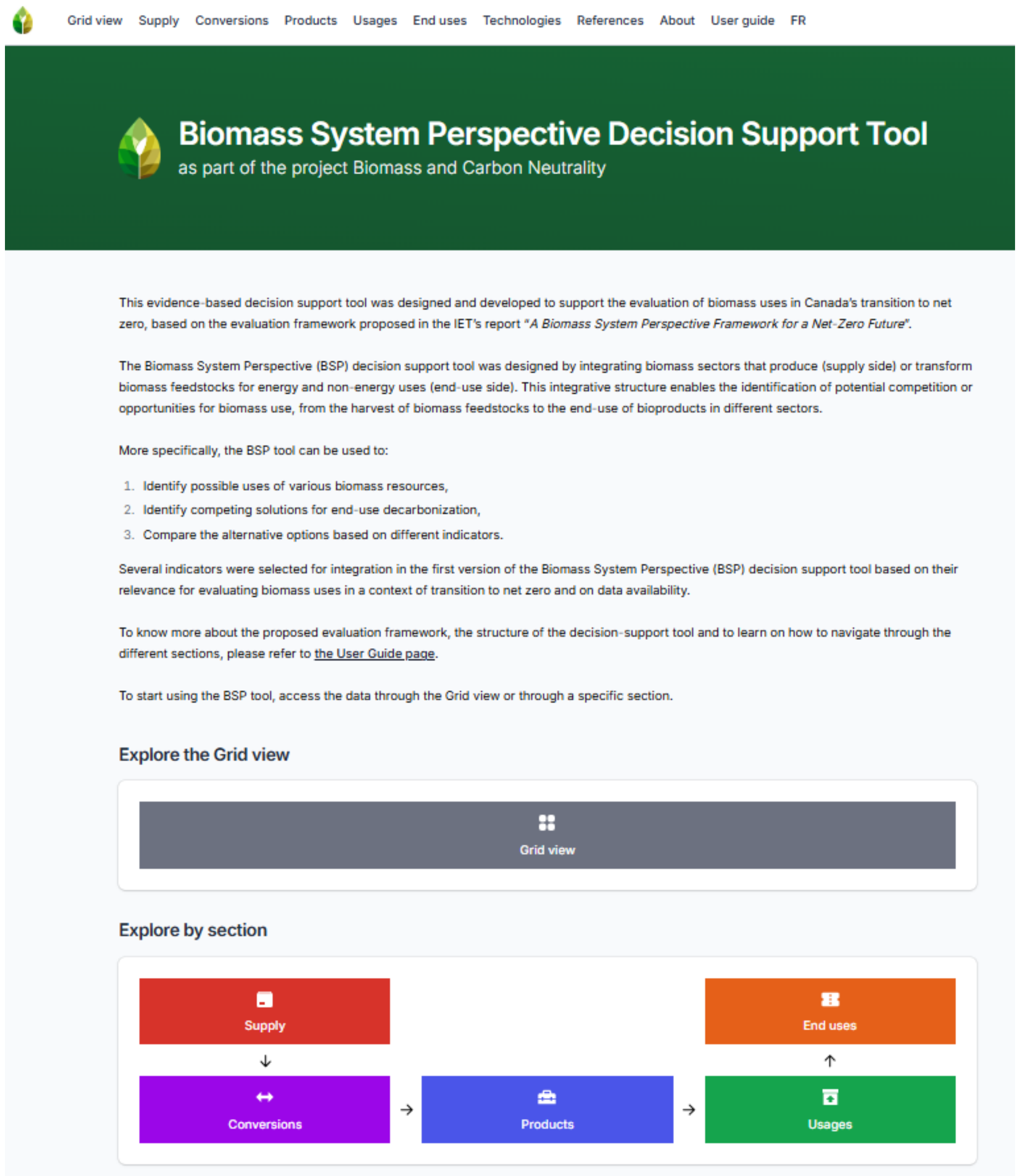
Download the user guide

The Biomass System Perspective decision support tool

This tool is publicly available and can serve as a common basis for evidence-based project evaluations.

To access the BSP online tool:

biomass-perspective-biomasse.ca



Recommendations

Through the work done in this project, many gaps and barriers were identified, which limit the evaluation and comparison of different biomass uses and the analyses of their potential contribution to decarbonization.

Recommendations are presented in the final report

- For addressing the gaps in evidence that can enhance the **integration of quality-data** in the Biomass System Perspective decision support tool

- For **actions beyond project analyses** that are necessary to ensure that all biomass sectors in Canada contribute to the transition to net zero

Access to quality-data

Recommendation : Improve data availability for biomass supply

Studies exploring decarbonization solutions or transition pathways for economic sectors in Canada often include biomass feedstocks as potential energy sources to meet demand.

The accuracy of projections depends on the data and assumptions used in the analyses.

However, information on biomass quantities is often hard to track, for several reasons:

- Variability and lack of precision in terminology employed for reporting biomass supply
- Lack of data on “emerging feedstocks”

Estimations of the available and accessible quantities of each type of feedstock, based on recent evidence, are essential for future analyses to accurately estimate the potential of biomass conversion pathways and reduce uncertainties about biomass potential for end-use sector decarbonization.

Access to quality-data

Recommendation : Impose transparency in carbon intensity reporting

- Carbon Intensity (CI) is the main indicator used to compare the impact of existing and emerging biofuels on GHG emissions.
- This metric is also used in government programs, such as the Clean Fuel Regulations, to set targets, track compliance of biofuel industries, and establish a credit market.
- It is currently challenging to track the CI of projects deployed in Canada and compare different projects because of the confidentiality of CI information.
- Approved CIs of projects under the Low Carbon Fuel Standard (LCFS) are regularly published in British Columbia. However, the publications do not specify which feedstocks were used to obtain the corresponding CI value. The CI of projects in Canada that were approved for the CFR are published only for the industries that agreed disclosing the information

A higher transparency in CI reporting under federal and provincial programs is needed to more accurately track the impact of bioenergy and compare different biopathways for biomass use in Canada.

From analyses to action

Recommendation : Put in place measures to ensure that the LULUCF sector reaches negative emissions

- Even when excluding natural disturbances, this sector is a net carbon source through the entire time series of the national inventory (Government of Canada, 2025).
- Croplands have historically been a net carbon sink in Canada in almost all years declared in the national inventory. High variability in emissions mainly occurs due to drought, which made 2022 an exception compared to previous years.
- Emissions from managed forests have been consistently higher than removals, and there are currently no regulatory targets or incentives driving efforts to reach zero or negative emissions in that sector.
- Projections published by ECCC show that emissions from the LULUCF sector are expected to reach negative emissions starting in 2023.

With foreseen increasing demand for biomass feedstocks, it is important to set clear objectives for emissions in the LULUCF sector ensuring that emissions from forest biomass harvest and use would evolve in the required direction: that is, a net carbon sink rather than a net carbon source.

From analyses to action

Recommendation : Establish a Biomass Strategy compatible with Canada's Net-zero commitment

Canada currently has no strategy for biomass use that sets out a vision for biomass role in reaching net zero emissions in 2050.

A national biomass strategy is needed to reduce uncertainties about the future role of biomass, the demand for bioproducts and to ensure coherence of Canada's actions and investments with its climate objectives.

More specifically, a Biomass Strategy for Canada needs to be established based on:

- Scenarios for biomass use that are compatible with a net zero future; and
- Projections of biomass availability across Canada in a changing climate;

As concluded through the research presented in this report, there is no one-size-fits-all solution for biomass uses. The impact of its use, from an ecological, social and economic standpoint, depends on the local context.

Canada needs a national Biomass Strategy based on regional analyses of different scenarios for biomass use across the economy that are compatible with a net-zero future and that account for projections of biomass availability in a changing climate.

Thank you for your attention

If you have any questions, comments or suggestions:

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